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Proceedings of the Inaugural Meeting Canadian Land Reclamation Association

DECEMBER 1975

Crop Science Department
Ontario Agricultural College
University Of Guelph
uelph, Ontario, Canada
March 1976

FORMERLY
PROCEEDINGS OF
THE ONTARIO COVER CROP COMMITTEE

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PROCEEDINGS OF THE INAUGURAL MEETING
OF THE
CANADIAN LAND RECLAMATION ASSOCIATION

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PRESIDENT'S MESSAGE

The inaugural meeting of the Canadian Land Reclamation Association was greeted with enthusiasm and optimism. Enthusiasm, knowing that a national organization had been formed which could act as the focal point and forum for the science and technology of land reclamation. Optimistic, hoping that the Association would bring together engineers, agronomists, foresters, and other disciplines to develop a viable organization useful to industry and government in the solution of numerous complex and varied problems in the field of land reclamation.

An interim executive was elected, a constitution was developed and accepted, and committees were formed to develop policy for publications, memberships, by-laws, aims and objectives. The University of Guelph was chosen for the first annual meeting in late 1976. In brief, the physical aspects are "in place". Although much work has yet to be completed in this area, it remains that the major concern should be that the optimism of the charter members is fulfilled.

The fulfillment of the optimistic views is a challenge -- a challenge that must be faced and will not be achieved in one or two years but must be the constant concern of present and future executives and by the membership at large. It is my considered opinion that the Association should 'take a leaf from the book' of the Ontario Cover Crop Committee which maintained a balance between the practical and theoretical approach to the problems in land reclamation. Theoretical research is needed to solve the many complex problems. It should be encouraged and conducted by members within the Association. The data and information must, however, be translated into practical terms and workable models. This philosophy necessitates a balanced participation of both industry and academic personnel on all future executives in order to maintain a balanced approach. Likewise, this philosophy of a practical but comprehensive approach to problems in land reclamation must be reflected in any and all publications issued by the Association.

It is through such an approach that the Canadian Land Reclamation Association will be useful, and appeal to those industries and government agencies involved in the fields of mining, conservation, construction for traffic, gas, oil and electricity, to name a few, which by necessity must disturb land and require reclamation programs in order to offset the increasing public demand for environmental protection.

As such, the Association will grow and develop into a viable organization capable of fulfilling the most optimistic views of the charter members. The degree of success will be contingent upon the effort and input of engineers, agronomists, foresters and other disciplines from university, industry and government.

J. E. Winch
President

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CANADIAN LAND RECLAMATION ASSOCIATION

Aims and Objectives

The objectives for which the Association is established are:

1. To further knowledge and understanding of problems and solutions in land reclamation through planning, design, biological, engineering and educational means.

2. To provide opportunities for those interested in and concerned with land reclamation to meet and exchange information, ideas and experiences.

3. To encourage the investigation of problems pertaining to land reclamation.

4. To stimulate the incorporation into planning and practice of advances resulting from research, experimental work and practical experience.

5. To collect information relating to land reclamation and publish any periodicals, books and leaflets which the Association may think desirable.

6. To encourage education in land reclamation.

7. To co-operate with any other organization in furthering any of the objectives of the Association.

8. To make and frame such regulations and by-laws as may be considered necessary for the conduct of the Association and the attainment of its objectives.

9. To admit to membership of the Association persons concerned with or interested in the objectives of the Association.

10. To do all such things as may be indicated or conducive to the attainment of the above objectives.

A MESSAGE FROM THE MEMBERSHIP CHAIRMAN

Dear Prospective Member,

In the next three decades Canadians can look forward to accelerated growth of surface mining activity and resource developments, expanding urban centres and increased utilization of natural areas for recreational purposes. Each of these activities brings with it unique and invariably complex land disturbance.

Today Canadians are in a favourable position to estimate the extent and nature of many of these disturbances. Many countries, from whom we can gain invaluable knowledge, have had to learn "after the fact". The opportunity is now better than ever to prepare ourselves with a broad knowledge of reclamation procedures which, when the need arises, will rapidly and effectively rehabilitate the land surface wherever and however disturbed.

Until the recent formation of the Canadian Land Reclamation Association no one group existed to act effectively as a focus for land reclamation activities in Canada. Information exchange on a Canada-wide basis on any topics related to reclamation has proven difficult. Regular meetings to exchange views, ideas and practical recommendations have been restricted to small audiences in isolated centres throughout the country. Exchange of news with reclamation efforts in other countries has not been adequately explored as a means of promoting expert input on Canadian reclamation problems. More people across Canada are required to convey the message of reclamation into all areas of the private and public sectors of our communities.

It has, therefore, been decided to institute the Canadian Land Reclamation Association in order to correct all the past inadequacies of information exchange and mutual participation. We believe that for the future of Canada, land reclamation is vitally important. We invite you to join us in the achievement of the Association's aims and objectives.

The Association has four categories of membership, as explained on the enclosed form. The dues are $15.00 (active),$10.00 (associate), and $5.00 (student), respectively. Any amount of $100 or more will be considered a sustaining membership. The CLRA offers anyone joining in the 1975/76 fiscal year, Charter membership in the Association at no extra charge.

We look forward to your reply.

Yours sincerely,

P. D. Lulman
Chairman,
Membership Committee

APPLICATION FOR MEMBERSHIP -- 1976

NAME: _____
(Surname) (First) (Initial)

ADDRESS: _____

_____

CATEGORY	1976 Fee Enclosed
Active	$ 15.00
Associate	$ 10.00
Student	$ 5.00

Active members enrolled in 1976 will be designated as Charter Members of the Canadian Land Reclamation Association.

Applications, membership dues (cheque/money order only, payable to the Canadian Land Reclamation Association) and enquiries regarding membership should be sent to:

Mr. P. Lulman
Chairman, Membership Committee
Canadian Land Reclamation Association
c/o Department of Crop Science
University of Guelph,
Guelph, Ontario, N1G 2W1
Canada

PRESENT EMPLOYMENT

Descriptive Title: _____

_____

Date of appointment to position: _____

_____

Resume of duties: _____

_____

PREVIOUS EMPLOYMENT (Active members only)

From	To	Position held	Employer
_____	_____	_____	_____
_____	_____	_____	_____

Editor's Message

NEWS ABOUT THE RECLAMATION REVIEW

Arrangements are well in hand for the publication of the new RECLAMATION REVIEW, successor to the Reclamation Research Newsletter and Bibliography.

As announced in RRL #10, the REVIEW will be published regularly by the Canadian Land Reclamation Association and will be received by all members of the Association. The target is four issues a year. The extent to which this is met will be determined by the availability of material.

The features included in the Reclamation Research Newsletter will be continued - viz., news items, notice of forthcoming events, requests for information, short abstracts of new publications, but also it is intended to publish original articles, and to include such additional details of new equipment, people on the move, etc., and indeed any items that are of interest to reclamationists world-wide and which are brought to the notice of the Editor.

An editorial board has been established for the review of articles submitted. Contributions are now invited. Original articles, items of interest, notices of forthcoming meetings and publications for notice in the REVIEW should be sent to the Editor at the address below:

Dr. J. V. Thirgood
Editor - Reclamation Review
Canadian Land Reclamation Association
Faculty of Forestry
University of British Columbia
Vancouver, British Columbia, V6T 1W5
Canada

Please help to get the REVIEW on the road. We need your contributions and,especially, original articles.

Minutes of a meeting attended by a group of persons interested in forming a Canadian Association for Land Reclamation

Meeting held on Tuesday, December 9th, 1975 in the Crop Science Department, University of Guelph, Guelph, Ontario

The following persons were in attendance:

Berry, C.B.	Great Canadian Oil Sands Ltd., Fort McMurray, Alberta.
Brooks, B.	Noranda Mines, Limited, Noranda, P.Q.
Courtin, G.M.	Laurentian University, Sudbury, Ontario.
Gardiner, R.T.	Cominco Limited, Trail, B.C.
Gardner, Robin	B.C.Power and Hydro Authority, Vancouver, B.C.
Gillespie, E.D.	Ontario Hydro, Toronto, Ontario.
King, L.M.	Canada Agriculture, Plants Products Division, Toronto, Ontario.
Klym, D.J.	Great Canadian Oil Sands Ltd., Fort McMurray, Alberta.
Laidlaw, Ted	Alberta Environment Conservation Authority, Edmonton, Alberta.
Lulman, P.D.	Syncrude, Ltd., Edmonton, Alberta.
McKitterick, W.J.	Otto Pick Seeds Ltd., Richmond Hill, Ontario.
Murray, D.R.	Department of Energy,Mines & Resources, Elliot Lake, Ontario.
Thirgood, J.V.	University of British Columbia, Vancouver, British Columbia.
Tucker, P.	University of Guelph, Guelph, Ontario.
Watkin, E.M.	University of Guelph, Guelph, Ontario.
Wilson, W.	International Nickel Company of Canada,Ltd., Copper Cliff, Ont.
Winch, J.E.	University of Guelph, Guelph, Ontario.

J. Winch and E. Watkin acted as Chairman and Secretary, respectively.

Several weeks prior to the meeting, those attending had received a proposed constitution which was to be used as a working document for the meeting. The various items contained therein, such as the name of the association, aims and objectives of the association, qualifications for number of officers, powers of an executive, etc., were considered and debated during the day-long meeting.

No formal motions were brought in at the meeting. The group was unanimous in its opinion that a Canadian Land Reclamation Association be formed and that the results of its meeting presented to the 5th Annual Workshop of the Ontario Cover Crop Committee on December 10th for consideration by those present at the workshop meeting.

Numerous changes were made to the working document circulated prior to the meeting. The document, with the appropriate changes, was rewritten and copies made for presentation at the afternoon session on December 10th, of the Ontario Cover Crop Committee.

Minutes of meeting held on Wednesday, December 10, 1975
during the 5th Annual Workshop, Ontario Cover Crop Committee
at the Arboretum Centre, University of Guelph

The purpose of the meeting was to discuss the proposal "that the Ontario Cover Crop Committee be dissolved and replaced by the Canadian Land Reclamation Association".

The meeting was chaired by J. Winch, University of Guelph, and E.Watkin, University of Guelph, acted as secretary.

J. Winch opened the meeting by outlining the reasons for it being called. At the Fourth Annual Workshop of the Ontario Cover Crop Committee, December 1974, suggestions were put forward concerning the formation of a Canadian Association, or Society, which would concern itself with the problems and solutions to land reclamation in the broadest sense. The chairman and secretary of the Ontario Cover Crop Committee (OCCC) were instructed to develop a working outline of a possible constitution for the proposed association, to circulate the constitution to the membership at large; to solicit comments and suggestions and to bring to the next annual meeting some concrete proposals concerning the need for and formation of an association.

The chairman and secretary discharged their duty by circulating the aforementioned instructions to the membership of the OCCC at large and calling for comments and suggestions regarding the proposed association. A working document outlining a possible constitution was written and circulated to those members who had offered comments and suggestions in writing. These latter members were invited to form a 'working group' concerned with the formation of a Canadian Association for Land Reclamation; the 'working group' convened on December 9th, 1975, prior to the Fifth Annual Meeting of the Ontario Cover Crop Committee.

A mimeographed outline of the proceedings of the meeting held on December 9th, 1975 was presented to those present for the workshop meeting. It consisted of the aims and objectives of the proposed association and a potential constitution.

The working group put forward several specific recommendations for consideration at the OCCC workshop meeting:

1. It was the view of the working group that an association is urgently needed, as no organization is in existence that is concerned with all aspects of land reclamation and it is their recommendation that such an association be formed.

2. The working group submit for consideration the attached "Revised Outline of the Constitution" of the Canadian Land Reclamation Association. It is

suggested that, following modification and discussion, a constitution be ratified by the membership.

3. It is the suggestion of the working group that an 'Interim Executive Committee' be elected at this meeting to expedite formation of and to conduct the business of the association.

4. It is suggested that if an association be formed, then the dues for the year 1976 be set at $15, $10 and $5 for Active, Associate and Student members, respectively.

Motion: That an organization concerned with land reclamation be formed and that a tentative title of the association be the Canadian Land Reclamation Association.

(Proposed - Thirgood; Seconded - Courtin)

Motion carried

A general discussion followed on the actual name of the association and on the aims and objectives as outlined in the proposed constitution.

Motion: That the name Canadian Land Reclamation Association be accepted and the objectives also accepted as amended by discussion.

(Proposed - Gardner; Seconded - Lulman)

Motion carried.

A general discussion occurred on the types of membership in the Association and the terms of reference for each type. Agreement was reached on the descriptive form for each membership category.

Motion: That the section of the proposed constitution dealing with membership categories be accepted with the discussed amendments.

(Proposed - Lulman; Seconded - Gardner)

Motion carried.

A general discussion followed on the remainder of the proposed constitution that included Election of Officers, Co-option to the Executive Committee, Powers of the Executive Committee, Quorum and Voting, Meetings, Audit and Amendments to the Constitution.

Motion: That the last two pages of the proposed constitution be accepted with the amendments discussed.

(Proposed - Brooks; Seconded - Courtin)

Watkin suggested that a rider be added to the above motion "that the revised constitution be presented for re-ratification by the general membership in 1976, and by which time a legal opinion be obtained on the legality of the constitution".

Motion carried.

Motion: That nominations be called for to form an interim executive for 1976 for the Canadian Land Reclamation Association.

(Proposed - Lulman; Seconded - Murray)

Motion carried.

Thirgood then proposed that the present chairman (Winch) and secretary (Watkin) of the Ontario Cover Crop Committee accept nomination as President and Secretary/Treasurer, respectively, of the Canadian Land Reclamation Association for 1976.

Proposal accepted by members present without formal motion and voting.

Nominations were then called for from the floor for the position of vice-president and for five executive committee members.

1 R.Gardner and J.Thirgood were nominated for the position of Vice-President. It was proposed from the floor that the non-elected person for the position of Vice-President be automatically appointed to fill one of the five executive committee positions. This proposal was accepted unanimously by the members present.

The names of Courtin, Lulman, Laidlaw and Bayles were proposed for nomination to the Executive Committee.

It was moved that the nominations listed for the position of President, Vice-President, Secretary/Treasurer and Executive Committee be closed and that the election of officers take place on Thursday, December 11, 1975 at the conclusion of the Ontario Cover Crop Committee Annual Workshop.

Motion: That the membership dues for 1976 in the Canadian Land Reclamation Association be:

Active - - - - -	$15.00,
Associate- - - -	$10.00, and
Student- - - - -	$ 5.00.

(Proposed - Howell; Seconded - Lulman)

Motion carried.

The meeting adjourned at 5:30 p.m., approximately.

CANADIAN LAND RECLAMATION ASSOCIATION

1st Business Meeting
Thursday, December 11, 1975
Arboretum Centre
University of Guelph
Guelph, Ontario

W. McKitterick acted as chairman of the meeting during electoral procedures.

Motion: That all persons present at the Ontario Cover Crop Committee Fifth Annual Workshop have voting powers to elect an interim executive for 1976 for the Canadian Land Reclamation Association.

(Proposed - Berry; Seconded - Michellutti)

Motion carried.

McKitterick asked if there were any further nominations for the position of President, Vice-President and Secretary/Treasurer. None were received.

McKitterick asked if there were any further nominations for position on the executive committee. The nomination of Howell was received.

Dr. Winch read out biographies on the two persons nominated for the position of Vice-President.

The names of persons nominated for positions on the executive committee were displayed on a board before the meeting.

Ballot papers were distributed on which electors had to write in the name of their choice for the position of Vice-President, and to write in four names of their choice for positions on the Executive Committee. (Electors were reminded that one position on the Executive Committee would be automatically filled by the candidate not elected for the position of Vice-President.

Klym, Murray and Stowe acted as collectors, counters and scrutineers of the ballot forms received.

After counting of the ballots, the Interim Executive of the Canadian Land Reclamation Association was announced, as follows:

President:	J. E. Winch	Executive Committee:	F. D. Bayles
			G. M. Courtin
Vice-President:	J. V. Thirgood		Robin Gardner
			Ted Laidlaw
Secretary/Treasurer:	E. M. Watkin		P. D. Lulman

A motion that all ballot forms be destroyed was carried.

J. E. Winch assumed chairmanship of the meeting from McKitterick.

Winch made a short speech in his capacity as President, outlining the tasks lying ahead for the executive in continuing to promote and organize the new Association and the role of the general membership in helping to achieve its aims and objectives.

Winch called for a motion from the floor that the Executive Committee be bound by the Constitution and permitted to act in good faith during the coming year as the by-laws of the Association had yet to be fully written and established.

Motion to the above proposed by Seraphim and seconded by Schumacher.

Motion carried.

Motion: That the officers of the Association be permitted to set up a bank account in the name of the Association and that the signing officers be any two of the President, Vice-President and Secretary/Treasurer.

(Proposed - Haras; Seconded - Brooks)

Motion carried.

Motion: That officers and members of the Executive Committee be partially or fully reimbursed for expenses incurred in attending meetings of the executive of the Association.

(Proposed - Berry; Seconded - Klym)

Motion carried.

Discussion took place as to when and where future annual meetings of the Canadian Land Reclamation Association should occur. There was a good consensus that the annual meeting of the Association should take place in late November/early December of each year. It was agreed that the first annual meeting of the CLRA should be held at the University of Guelph in 1976.

The meeting adjourned at 4:30, approximately.

PROPOSED CONSTITUTION

OF THE

CANADIAN LAND RECLAMATION ASSOCIATION

FOR RATIFICATION AT THE

1ST ANNUAL MEETING
LATE NOVEMBER/EARLY DECEMBER 1976

GUELPH, ONTARIO, CANADA

CANADIAN LAND RECLAMATION ASSOCIATION

Name: The name of the association is the Canadian Land Reclamation Association.

(Land reclamation is defined as the rehabilitation of disturbed lands).

Objectives: The objectives for which the Association is established are:

1. To further knowledge and understanding of problems and solutions in land reclamation through planning, design biological, engineering and educational means.

2. To provide opportunities for those interested in and concerned with land reclamation to meet and exchange information, ideas and experiences.

3. To encourage the investigation of problems pertaining to land reclamation.

4. To stimulate the incorporation into planning and practice of advances resulting from research, experimental work and practical experience.

5. To collect information relating to land reclamation and publish any periodicals, books and leaflets which the Association may think desirable.

6. To encourage education in land reclamation.

7. To co-operate with any other organization in furthering any of the objectives of the Association.

8. To make and frame such regulations and by-laws as may be considered necessary for the conduct of the Association and the attainment of its objectives.

9. To admit to membership of the Association persons concerned with or interested in the objectives of the Association.

10. To do all such things as may be indicated or conducive to the attainment of the above objectives.

Proposed Constitution
Canadian Land Reclamation
Association

Membership

1. Membership of the Association will be open to those desirous of contributing to the well-being of the Association and who, or who, have been contributing purposefully to land reclamation through their work in scientific, practical and administrative fields.

2. There shall be five types of membership:

    1. Active
    2. Associate
    3. Student
    4. Honorary
    5. Sustaining

Active members are individuals who are involved in land reclamation and who have remitted their annual dues to the Treasurer. Active members may attend all Association meetings, vote on all matters pertaining to the Association, and hold office.

Associate members are individuals who are interested in land reclamation and who have remitted their annual dues to the Treasurer. Associate members may attend all Association meetings but may not vote on matters pertaining to the Association and may not hold office.

Student members are individuals who are interested in land reclamation and are registered in a recognized educational program. Student members may attend all Association meetings but may not vote on matters pertaining to the Association and may not hold office.

Honorary membership may be awarded by the Executive Committee to individuals for meritorious services to land reclamation and/or the Association. Honorary members shall have the privileges of active members.

Sustaining members: Societies, associations, municipalities, companies, partnerships, institutions, public bodies, government departments or ministries, and similar bodies having sympathy with the aims and objectives of the Association, may become sustaining members. A sustaining member shall have the privileges of one Associate Member.

Proposed Constitution
Canadian Land Reclamation
Association

Dues

1. Dues for Active, Associate and Student membership shall be paid on an annual basis to the Secretary/Treasurer.

2. The amount of dues for each year for the Active, Associate and Student membership shall be established by the Executive Committee, and any change in dues shall be submitted to the Annual General meeting for ratification.

Constitution of the Association

The affairs of the Association shall be managed by an elected Executive Committee which shall consist of the Past President, President, Vice-President, a Secretary/Treasurer and five (5) members. All officers and Executive Committee members shall be voting members of the Association.

Election of Officers.

1. The President and Vice-President shall be elected annually.

2. The Secretary/Treasurer and five voting members shall be elected for a period of two (2) years.

3. The outgoing President may remain on the Executive Committee to act as Past President.

4. A nominations committee shall be formed and consist of the Past President, who will act as chairman, and a minimum of two voting members appointed by the Executive Committee. The nominations committee shall submit names for all elected positions of the Association.

5. A membership committee shall be formed and consist of three (3) voting members. The committee shall review applications for membership and communicate their recommendation to the Executive Committee.

6. Other committees may be constituted by the Executive Committee when deemed necessary by the membership at large.

7. Any two voting members may nominate any voting member to serve

Election of Officers (continued)

on the Executive Committee or other committee of the Association. Nominations shall be sent in writing to the nominations committee and shall include the written acceptance of the nominee.

8. Voting for nominees for positions on the Executive Committee shall be conducted by postal ballot. The results of the postal ballot shall be made known at the Annual General Meeting.

9. Voting for nominees for positions on other constituted committees shall be by secret ballot at the Annual General Meeting.

Co-option to the Executive Committee

The Executive Committee shall have power to co-opt not more than three (3) voting members at any one time for specific purposes.

Powers of the Executive Committee

The Executive Committee shall have and may exercise and perform the following powers and duties, namely:

1. Commence, postpone and cancel meetings;
2. Conduct the business and carry out the objectives of the Association;
3. Appoint special committees;
4. May issue publications devoted to or bearning upon any objective of the Association;
5. Control the use of properties, seal, official symbol(s), letterhead, titles and monies of the Association.

Quorum and Voting

1. A quorum of the Executive Committee shall consist of five (5) members, two of whom must be officers of the Association and one of these officers shall be the presiding officer.

2. A quorum of the Annual General Meeting shall be of those voting members present.

3. Voting at Executive Committee meetings and at the Annual General Meeting shall be by simple majority. In case of a tie vote, the Chairman shall cast the deciding vote.

Proposed Constitution
Canadian Land Reclamation
Association

Meetings

1. The Executive Committee shall convene and hold an Annual General Meeting and such other meetings as they may consider necessary.

2. If so requested in writing by at least ten (10) voting members, the Executive Committee shall convene an Extra-ordinary General Meeting within 60 days following receipt of the request by the Executive Committee.

3. All Executive Committee and Annual General Meetings shall be recorded by means of formal minutes.

Audit

1. Accounts shall be kept of all monies received and expended by the Association. Two auditors who are not officers or members of the Executive Committee and who need not be members of the Association shall be appointed annually at the Annual General Meeting and shall be eligible for re-appointment.

2. A statement showing the financial position of the Association, examined and certified by the auditors, shall be laid before the Annual General Meeting and published in the Association's publication or mailed to all members.

3. The fiscal year of the Association shall be from September 1 to August 31.

Amendments to the Constitution

A proposed amendment to the constitution shall be submitted in wrigint to the Secretary/Treasurer ninety (90) days prior to the Annual General Meeting and shall require the support of at least five (5) voting members.

STABLE SEED SHEETS -
AN ALTERNATIVE APPROACH TO REVEGETATION

F.D.Bayles & M. A. Dudley
Canada Wire and Cable Limited
Technology Development Department
Noranda Research Centre
Pointe Claire, Quebec

INTRODUCTION

Mining and public works activities inevitably result in the disturbance of large areas of land. This in turn entails a responsibility by the parties involved to reclaim the land to a reasonably aesthetic and productive condition. The major objective is to provide a permanent self-sustaining plant cover which will serve the dual purpose of stabilizing the land surface as well as providing habitat for wildlife. It is obvious that these requirements are as necessary for mining operations as they are for embankment and right of way seeding as undertaken by utilities and public works departments.

Erosion can be caused by one or more of three circumstances: wind, water and rain, and human interference in nature. Under natural conditions, uncompacted soils or graded surfaces which are not adequately consolidated by plant growth are very susceptible to wind and water erosion. When the natural structure of the ground surface is altered during highway construction or the formation of dams for mine tailings settling ponds, it is necessary to rapidly and permanently stabilize the new formations to reduce the continued maintenance requirement and redevelop the natural setting.

Attempts have been made to find and consolidate soils with oils (1), refinery residues (1), cements (2), plastic foams (3), synthetic polymer emulsions (4), and chopped glass(5), but it may be stated that, in general, their efficacy in relation to the work needed to apply them, renders them quite uneconomical (1); as well, the binders seldom maintain or reconstitute the fertility of the soil. One of the more effective approaches to solving the problem has been by hydroseeding (6), or the application of water slurries of seed, fertilizer and mulch, sometimes in admixture with polymeric binders. This technique, however, is relatively expensive, is susceptible to operator skill, and quite often must be repeated if natural or application erosion causes damage before the vegetation has grown sufficiently to consolidate the surface (1,7).

The approach taken in this study was to develop a single system which would simultaneously provide a simple means of uniform seed and fertilizer distribution while at the same time binding the soil to be revegetated prior to the formation of a stabilizing root matrix. To achieve this, the concept of a water-soluble, flexible and inert polymeric sheet containing seed, fertilizer, herbicides and other additives necessary and useful for the speedy development of an erosion controlling ground cover was developed. The stable seed sheet is laid on the ground and provides, for a finite time, a consolidating effect and a microenvironment conducive to germination and growth.

Previous attempts to develop such a product by other workers have met with only limited success when applied for erosion control; one such approach, intended primarily to make consolidated turf for transport elsewhere, locked seed and fertilizer to an inert woven backing, using polymeric adhesives. This mat was then laid on the ground and covered with soil. The well known commercially available seed tapes, more closely akin to stable seed sheets, are deficient in having high raw material cost, no consolidating or stabilizing effect, limitations in seed size and distribution during encapsulation, and the need for burial in order to perform satisfactorily.

It is also felt that the seed sheet system to be described herein could be useful in transporting correctly proportioned and distributed seed/fertilizer mixtures to underdeveloped countries as part of aid programs, and be capable of application with minimal skills; no such product is presently available for aiding needy nations in crop or forage growth.

EXPERIMENTAL DEVELOPMENT

To more clearly understand the stable seed sheet concept, it is preferable to divide the study into three parts: (1) development of the sheet matrix; (2) germination studies; (3) pilot size commercial operations.

1. Development of Sheet Matrix

Initial experiments concentrated on the evaluation of potential candidate water-soluble polymers for use as the continuous phase of the seed sheet. These included carboxymethyl cellulose, hydroxypropyl cellulose, poly(vinyl acetate), poly(ethylene oxide) and poly(vinyl alcohol). These polymers were made up as solutions or dispersions in water at various con-

centrations, depending on polymer type and molecular weight, cast into sheets of nominal 0.001 inch dry film thickness, air dried and evaluated for film forming ability, flexibility, ease of resolutilization and relative degree of inertness towards the other ingredients, both during processing and after long-term storage. The majority of the films made had poor flexibility, which was overcome by the incorporation of a compatible plasticizer chosen from the family of poly (ethylene glycol)s, which acts to

(a) improve the hygroscopicity of the film, and

(b) overcome the relatively strong, rigidizing secondary valence forces occurring between adjacent molecules.

Among other plasticizers having potential utility are ethylene glycol, glycerine and urea. A short series of experiments established that the optimum concentration of plasticizer was between 10 and 25% by weight of total film former, depending on polymer, and plasticizer molecular weight. Table 1 lists a series of early seed sheet compositions, using various polymeric film formers. One can note the general trend to satisfactory films using poly (vinyl alcohol). These initial sheets, where noted, contained a recommended 10:20:20 fertilizer blend which, due to excessive levels of soluble salts, caused whitening and embrittlement.

Considering the performance results and relative costs of the various film forming candidates, it was decided to concentrate on poly (vinyl alcohol) as the prime candidate. Although this polymer is described exhaustively elsewhere (8), a brief resume of its nature is warranted.

Poly(vinyl alcohol) is not produced, as might be expected, by polymerization of vinyl alcohol monomer, but by hydrolysis, under controlled conditions, of solutions or dispersions of poly(vinyl acetate),a common ingredient in adhesives and latex paints. This treatment results in long chain polymers having pendant side chains terminating in hydroxyl groups, interspersed with unattached acetate ester groups. The basic properties of poly(vinyl alcohol) depend on two factors: the degree of hydrolysis (DH), and the degree of polymerization (DP). DH values for poly (vinyl alcohol) may be conveniently subdivided into two main classifications, (a) a partially hydrolyzed type having a DH of from 80-89%, normally soluble in cold and hot water, and (b) a fully hydrolyzed type having a DH of above 98%, soluble only in hot water. In terms of DP, the major sub types are low, medium and high viscosity grades which allow their use in a variety of applications. A further advantage of poly(vinyl alcohol) was that it had already been cited (8) as useful in soil conditioning, where it "improves the physical characteristics of single grained soils by converting them to a crumbed form and imparting water stability. This crumbed structure has excellent air and water permeability,

high water retaining capacity, and high water and wind erosion resistance. This results in improved plant growth, with better germination, easy tillage, lower incidence of disease, rapid growth and improved crop quality. Poly (vinyl alcohol) is most effective for use with loam with a high clay content, clayey loam and clay."

For use in the stable seed sheet program, it was recognized that the optimum polymer form of poly(vinyl alcohol) should be partly hydrolyzed and of low or medium molecular weight; studies concentrated on this material.

As previously mentioned, the early sheets were made by air drying the cast solutions. This resulted in drying times well in excess of 8 hours. As this was not economically viable, studies concentrated on attempts to dry the sheets at elevated temperatures. The major obstacle to be overcome was the removal of the large volume of water in the casting solution, a situation caused both by the relative insolubility of poly(vinyl alcohol) in any other solvent which would not detrimentally affect seed viability and the need to use relatively low concentrations of polymer. It was also found, both from literature surveys and experiments, that temperatures in excess of 180°F, or extended exposure times at high temperatures, resulted in loss of seed viability. Thus a third major restriction was introduced by the decision to restrict temperatures to no greater than 150°F.

Further experiments established that significant reductions in drying time could be effected by using convection ovens at 150 F. However, these times were still excessively long. It was realized that this was due to the buildup of saturated atmospheres in the oven which retarded drying. When single pass forced draft ovens were employed, further significant reductions in time were effected. Table II illustrates selected experiments which show the relative effects of oven type on drying time. Although these drying times resulting from forced draft drying were a significant improvement over the other methods, the best, 25 minutes, was still unacceptable long. A further series of experiments then evaluated the concept of starting with a polymer solution preheated to 150°F, and a solids content higher than the average 6% by weight employed in previous series. It can be clearly seen from Table III that this approach provided the key to successfully reducing oven residence times to acceptable levels. Although there were minor problems to be overcome in seed slurry dispersion in these highly viscous, high solids solutions, germination experiments and the successful reduction of residence time indicated that the process was viable and warranted further study on a pilot scale.

2. Germination Studies

From the beginning, the stable seed sheet concept assumed that seed would be encapsulated in a continuous matrix of water-soluble polymer, and that this sheet would be produced by drying from cast, aqueous solutions. The critical factor was whether or not this approach would effect significant changes in seed viability.

To study the effects of various approaches to manufacturing seed sheets on seed viability, seed beds were prepared in the greenhouse facilities of the Pulp and Paper Research Institute of Canada in Pointe Claire, Quebec, whose co-operation is gratefully acknowledged. These were portable flats, 4" x 36" x 58", which were lined with randomly pierced polyethylene sheet to retain the soil, and filled to a depth of 4" with a mix of 75% by volume clayey loam and 25% by volume of peat moss. The sheets, appropriately identified, were laid on top of the medium, and watered with controlled aliquots of D.I. water for the first ten days, and every fifth day thereafter. First visual germination was monitored, as was the degree of subsequent germination, vigor and quality of root growth after 30 days. The environment was maintained at an average 12-hour day, artificially augmented,where necessary, with temperatures for day and night, controlled at 75°F/60°F, respectively. In this, and all subsequent studies, except where noted, the seed used was a commercial lawn mix made up of fescues, ryes, bent grasses and clover. The seed loadings were maintained at the commercially recommended broadcast rate.

Table IV shows the results of germination studies of the first series of slurry cast, air dried sheets as described in Table I. In Table IV, the fertilizer, marked with an asterisk, is a commercial 10:20:20 blend, P(VOH) is poly(vinyl alcohol), CMC is carboxymethyl cellulose, and P(VAC) is poly(vinyl acetate). Germination is in days after placement of the sheet, total germination is a subjective assessment of the relative quantity of seed germinated after 15 days as a percentage. Vigor after 15 days is a subjective assessment of the strength of the growth. Root growth is assessed after 30 days by removing the growth from the test flat, shaking free of soil and subjectively rating volume and entanglement of roots, and their length. It can be seen that the trend was to generally good results using poly(vinyl alcohol) as the sheet matrix, although this was a function of molecular weight and the presence of fertilizer. The relative disparity in germination time was explained by noting that the seed was found to have retained a light coating of polymer which, depending on the speed of dissolution, was swelling and imbibing water at different rates, thus controlling onset of germination. In general, sheet disintergration occurred within minutes of laying the sample on the soil. On Day 15, soil integrity was uniformly good, as monitored by subjective compression and disintegration tests.

A further series of experiments evaluated the ability to agglomerate soil by laying selected seed sheets, accompanied by a control, on an artificial bank inclined 30° from the horizontal. The effects of severe watering on seed retention and germination were monitored and are shown in Table V. It may be noted that the control growth seemed better as it was dense and heavily watered at the base of the bank. The experimental plots, however, were uniform and healthy with good soil integrity.

As mentioned in the section describing sheet matrix studies, economic viability of the seed sheet concept required short drying times. A series of experiments, described in Table VI, studied the effects of temperature and oven residence time on seed viability. Germination was determined in petri

dishes containing damp glass wool, recording days to germination and percentage visual germination after 15 days. The seeds were placed in a convection oven as is, or prewetted with water. It is quite apparent that a significant deterioration of seed viability occurred between 150°F and 200°F which substantiates similar studies reported in the literature (9, 10). On the basis of these data, the decision was made to use a maximum drying temperature of no greater than 150°F.

Recalling Table II, which described the study to evaluate the comparative efficacy of convection oven drying to forced draft oven drying, a further series of germination experiments were prepared from this series to evaluate the effects on seed viability. Growing conditions in the greenhouse were comparable to the previous series. The overall results are shown in Table VII. Visual germination was rated as a percentage of seed applied, after 10 and 20 days, and vigor of germination after 10 days. Root quality was subjectively evaluated after 30 days. From the data in this table, it may be seen that both the air dried sheets, series 1, 4, and the forced draft dried sheets, series 2, 4, showed good germination which, although somewhat slower than the controls, was comparable after 20 days of growth. The vigor of growth and root quality was equivalent. The convection oven dried series, #3, 6, was, however, uniformly poor in all aspects of growth. It was thus concluded that little effect on growth could be anticipated from the use of high velocity air streams for drying. Further studies were then made to evaluate various other parameters pertinent to pilot studies of continuous sheet production. Although not described in detail, it was found that maintaining a regular watering schedule during the critical first days of germination was vital to vigorous growth. Soaking the seed for extended times in plasticizer or polymer had little effect on germination or vigor. Excessive residence times in the oven, as might be expected if the line stopped, were detrimental, reducing germination by as much as 50%. Presoaking seed in water for 24 hours before casting into sheet, in an effort to encourage germination, had no positive effect. Modifications to the drying ovens to effect increased air velocity were not detrimental, although, as previously mentioned, temperatures in excess of 150°F, even for short residence times, severely retarded germination and growth. The addition of surfactants to effect improved dispersion of the seed during drying had no detrimental effect. Most importantly, as may be recalled from the sheet matrix section, sheet made from solutions of up to 21% by weight of film former showed equal vigor and growth to both broadcast controls and sheet controls made from lower solids content solutions.

Seven varieties of seed most frequently used in revegetation were cast into sheets at the recommended loadings to examine the effects of encapsulation on germination and growth. The results of this study, detailed in Table VIII, indicate that, in general, dicotyledons germinated more quickly but showed poor root formation, whereas monocotyledons had slow germination rates but excellent root growth. Most importantly, however, there was little effect on germination or growth by encapsulation in a seed sheet.

3. Pilot Studies of Continuously-Made Seed Sheets

Experiments were conducted at the pilot facility of the Sandvik Corporation in Fair Lawn, New Jersey, to elucidate the following parameters:

(i) to verify the production feasibility of seed sheet in continuous lengths of controlled thickness;

(ii) allow measurements for the sizing of production equipment and determination of production rates; and

(iii) obtain an accurate estimate of the cost of production equipment and thereby a production cost for the seed sheet.

A schematic diagram of the production facility is shown in Figure 1. Using this equipment, which produced sheet 18" wide, successful manufacturing trials of many hundreds of feet of continuous sheet were concluded. It was found possible to produce sheets of 0.001" thickness with average oven residence times of ~ 2 1/2 minutes and sheet temperatures which did not exceed 150°F, using polymer solutions of approximately 20% solids by weight. Germination studies in the greenhouse using sheets containing Baron Bluegrass indicated that, for the optimum formulations, first germination occurred in 5 days and percentage germination after 18 days was approximately 50%; control values were 5 days and 60%, respectively. In outdoor growth trials, experimental sheets germinated in 9 days and showed percentage germination after 18 days of up to 75%; control values were 9 days and 85%, respectively. Comparative cost studies indicate that the sheet production, ground preparation and laying of sheets are competitive with other techniques used in mine tailings revegetation.

In conclusion, water-soluble seed-containing polymer sheets have been successfully prepared, which are stable, easily stored and easily applied, both from roll and cut sheet form. With proper formulation they may be used in a variety of climactic areas having a wide range of precipitation conditions to give a controlled speed of resolubilization and provide the required amount of soil cohesion prior to root matrix formation. Furthermore, they allow a uniform distribution and optimum concentration of seed and additives to be applied simply and in a reproducible manner, which suggests potential value in revegetation or food crop production in underdeveloped countries.

This product, and its technique of manufacturing, are covered by patents pending, and Canada Wire and Cable is actively exploring sale or license of the technology.

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TABLE I

FLEXIBLE SEED SHEET COMPOSITIONS

Code	Ingredients, wt.%					Thickness, in.	Appearance
	Binder	Plasticizer	Seed	Fertilizer	Water		
1A3	3.4	0.9	1.9		93.8	0.001	Flexible, clear sheet
1B3	3.3	0.8	1.8	4.3	89.8	0.0025	Fairly brittle sheet, white
2A2	4.13	0.73	3.0	-	92.15	0.001	Fairly stiff, clear sheet
2A3	5.51	0.98	2.67	-	90.85	0.0015	Fairly stiff but strong sheet
2B3	5.18	0.92	2.51	5.86	85.52	0.0025	Fairly stiff and brittle, white
3A2	2.49	0.35	4.62	-	92.53	0.00075	Flexible clear sheet
3A3	3.67	0.55	4.56	-	91.22	0.001-0.0015	Very flexible, clear sheet
3B3	3.32	0.49	4.12	9.61	82.46	0.00125	White, fairly brittle sheet
4A3	3.29	0.59	3.38	-	92.74	0.002	Film white and quite brittle
4B3	3.05	0.54	3.13	7.31	85.96	0.0015	Film white and brittle
5A3	11.58	-	3.53	-	84.89	0.004	Film clear, slightly tacky, very flexible
5B3	10.69	-	3.26	7.61	78.44	0.004	Film white, stiff, slightly tacky
6A3	2.58	0.30	3.46	-	93.66	0.0008	Film clear and flexible
7A2	4.39	0.49	1.9	-	93.22	0.002	Film clear and flexible
7B2	4.21	0.47	1.82	4.25	89.25	0.002	Film white and quite brittle
9B3	6.73	-	2.68	6.25	84.34	0.0025	Flexible, white sheet

Binders Employed:

Series 1: Slow solubilizing poly(vinyl alcohol) (Grade 1)
2: Slow solubilizing poly(vinyl alcohol) (Grade 2)
3: 1:1 blend of the above binders
4: Carboxymethyl cellulose
5: Poly(vinyl acetate)
6: Fast solubilizing poly(vinyl alcohol) (Grade 1)
7: Fast solubilizing poly(vinyl alcohol) (Grade 2)
9: 1:1 blend of fast solubilizing poly(vinyl alcohol) and poly(vinyl acetate)

TABLE I

TABLE II

EFFECTS OF DRYING MODE ON OVEN RESIDENCE TIME

(6% aq. solutions of film former)

Polymer Type	Plasticizer Employed					
	Low MW Poly(ethylene glycol)			High MW Poly(ethylene glycol)		
	Drying Mode			Drying Mode		
	Time to Dry (minutes)					
	ON*	FDO	CO	ON	FDO	CO
Poly(vinyl alcohol) Type 1	B1 (>120)	B2 (25)	B3 (95)	B4 (>120)	B5 (30)	B6 (110)
Poly(vinyl alcohol) Type 2	D1 (>120)	D2 (30)	D3 (135)	D4 (>120)	D5 (25)	D6 (120)

*ON = Overnight at ambient temperature

FDO = Forced draft oven, 2100 CFM/150°F

CO = Convection oven, 150°F

TABLE III

OVEN RESIDENCE TIME AS FUNCTION OF CASTING SOLUTION SOLIDS CONTENT

Resin	Plasticizer	Ratio	Solids Content, %	Retention Time, min.	Temperature, °F
205	PEG 600	75:25	6.5	16	150
205	PEG 600	75:25	7.22	13	150
205	PEG 600	75:25	8.12	11	150
205	PEG 600	75:25	9.28	8.5	150
205	PEG 600	75:25	10.82	6.5	150
205	PEG 600	75:25	13.00	5	150
205	PEG 600	75:25	16.25	4	150
205	PEG 600	75:25	21.6	3.5	150
205	PEG 600	75:25	28.0	2.25	150

TABLE IV

GROWTH EXPERIMENTS ON SELECTED INITIAL SEED SHEET FORMULATIONS

Sheet Code	Composition	Germination (days)	Total Germination (%)	Vigor After 15 Days	Root Growth After 30 Days
Control	-	4	∿ 90	Excellent	Heavy
Control	Fertilizer (*)	5	∿ 85	Excellent	Heavy
1A3	P(VOH) slow sol.	5	∿ 80	Very good	Heavy
1B3	P(VOH) slow sol. +*	6	∿ 60	Good	Very heavy
2A2	P(VOH) slow sol.	6	∿ 50	Poor	Poor
2A3	P(VOH) slow sol.	7	∿ 50	Poor	Poor
2B3	P(VOH) slow sol. +*	7	∿ 60	Excellent	Heavy
3A2	Blended 1 & 2	6	∿ 70	Very good	Poor
3A3	Blended 1 & 2	5	∿ 80	Excellent	Heavy
3B3	Blended 1 & 2 +*	6	∿ 50	Poor	Poor
4A3	CMC	5	∿ 60	Very good	Good
4B3	CMC +*	6	∿ 60	Very good	Good
5A3	P(VAC)	8	∿ 10	Very poor	Very poor
5B3	P(VAC) +*	8	∿ 10	Very poor	Good
6A3	P(VOH) fast sol.	5	∿ 85	Excellent	Very good
7A2	P(VOH) fast sol.	6	∿ 90	Excellent	Good
7B2	P(VOH) fast sol. +*	7	∿ 70	Very good	Good
9B3	Blend P(VOH) + P(VAC) +*	9	∿ 30	Poor	Poor

TABLE V

RELATIVE PERFORMANCE OF SEED SHEETS ON 30° INCLINE

Sheet Code	Germination (days)	Visual Appearance (10 days)	Visual Appearance (18 days)	Soil Integrity
Control	5	Heavily washed down germination at bottom	Heavy growth at bottom	Poor, eroded
1	8	No seed displaced; uniform germination	Good uniform growth	Good
2	5	Ditto	Ditto	Good
3	6	Ditto	Ditto	Good

Watering Schedule: 4 times aliquot used on flats, applied from top of test area, once a day for first 10 days, every fifth day thereafter.

TABLE VI

EFFECTS OF THERMAL TREATMENT ON SEED VIABILITY

Treatment		Days to Germination	% Visual Germination
Control		5	∿ 95
Control wet with water, air dried		5	∿ 95
100°F/120 min.	Dry	5	∿ 80
	Prewet	6	∿ 75
150°F/45 min.	Dry	5	∿ 80
	Prewet	6	∿ 80
200°F/15 Min.	Dry	5	∿ 60
	Prewet	5	∿ 70
250°F/15 min.	Dry	6	∿ 20
	Prewet	6	∿ 15
300°F/15 min.	Dry	-	0
	Prewet	-	0
300°F/1 min.	Dry	-	0
	Prewet	-	0

TABLE VII

COMPARATIVE GROWTH TRIALS OF SELECTED SERIES OF SHEETS PREPARED USING VARIOUS OVEN DRYING TECHNIQUES

(Refer to Table II)

Sheet Code	Visual Germination, %		Vigor of Growth	Root Quality
	10 days	20 days	10 days	30 days
B1	35	85	Excellent	Very good
D1	25	85	Excellent	Good
B2	20	90	Good	Very good
D2	30	85	Excellent	Very good
B3	-	-	None	None
D3	15	40	Poor	Very por
B4	40	90	Excellent	Excellent
D4	40	85	Excellent	Excellent
B5	30	85	Good	Very good
D5	25	85	Good	Very good
B6	-	-	None	None
D6	∿ 2	∿ 2	Poor	Very poor
Controls				
1	60	95	Excellent	Good
2	60	95	Good	Very good

TABLE VIII

EFFECTS OF ENCAPSULATION ON GERMINATION AND GROWTH OF SELECTED SEED

Seed Type		Germination After 22 days, %	Root Matrix Formation (22 days)
Alfalfa		20	Good
	C.	20	Fair
Dogtooth		80	Good
	C.	80	Good
Baron Bluegrass		90	Good
	C.	90	Good
Alaska Clover		80	Good
	C.	70	Good
Sweet Clover		40	Good
	C.	40	Poor
Crown Vetch		3	Poor
	C.	5	Poor
Birds Foot Trefoil		40	Good
	C.	40	Good
Fairway Mix*		60	Good
	C.	60	Good

Line identifying seed type is experimental sheet.
C = Control

* 40% blue grass
  30% creeping red fescue
  20% ryegrass
  10% colonial bent grass

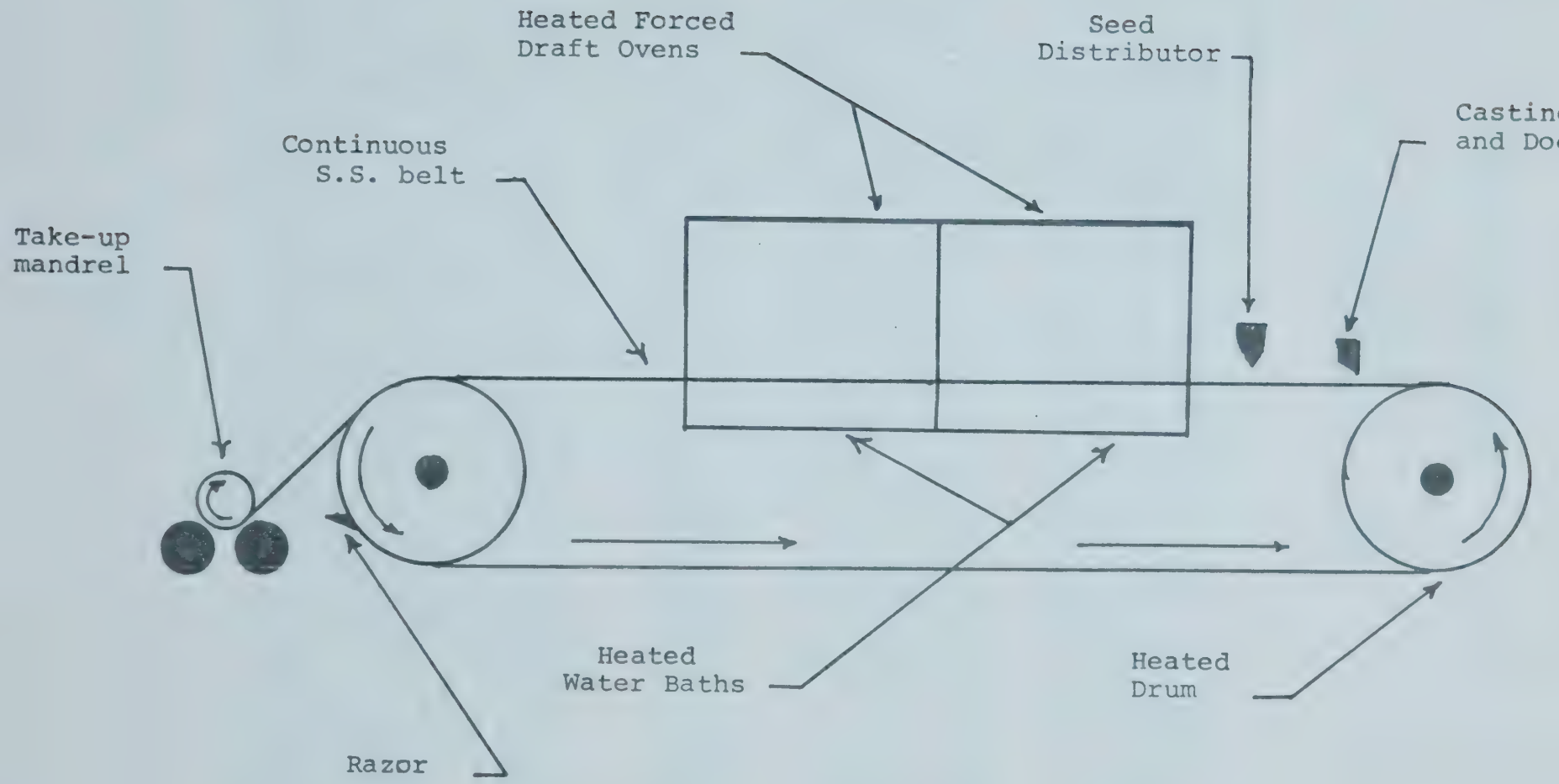

Figure 1. Schematic of the pilot line

FIGURE 1

SEEDS FOR RECLAMATION

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Grassland Philosophy

The contribution of good grasslands to soil conservation should not be minimized. A plant community that forms a closed canopy is probably the best deterrent to soil erosion that man can devise. Well nodulated legumes contribute substantial amounts of N to the system, while grasses are thought to contribute much less. However, it has been shown that free-living, N-fixing bacteria accumulate atmospheric N at a considerable rate in a grass community, especially under humid, tropical conditions.

A grassland plant community protects the soil from wind and water erosion, adds some N to the system, and also improves soil structure and tilth. This improved soil condition is the result of interactions of living and dead plant roots, micro-organisms, and soil. When grassland agriculture is practiced intensively, organic matter is renewed, soil erosion prevented, gully formation arrested, and soil tilth improved; therefore, soil conservation becomes an opportunity instead of a problem. Grass, when properly used, counters the devastating influence of erosion.

Grassland improvement has an essential role to plan in increased agricultural production. We are a meat-eating and milk-drinking nation, and grasslands provide the major raw material for production of beef and dairy products on land that cannot be used under intensive cultivation and in areas too far north for corn and bean production.

Due to increased world population, humans are competing with livestock for feed grains. The pressure of people on the world's food supply is a powerful force. The pressure of housing and cities on the good lands in North America will result in less productive land being pressed into production. The cities apparently will expand on all land close to cities because cities generate jobs and opportunities, and governments are forced to provide houses close to factories. The growth of cities is an amoeba-like system that slowly but surely expands. This factor will result in poorer soils being used for food production, and food production will probably have to come from land that we now consider to be too poor to farm. This increased production must come as a result of forages being fed to livestock. It would appear that the days of high grain ration being fed to ruminants is gone.

A sound, national grassland philosophy must be developed before grassland agriculture will be practiced generally on individual farms. I realize that most people at this workshop may not be agriculturalists, but I also feel that your ultimate goal should be to produce roughage that can be used to produce food products. The fact that the reclaimed land can be used in food production will do many things, such as appease public opinion in the short term and, in the long term, may well supply food for the world community.

Soil and climate, together with factors governing production and utilization of grasses and legumes, determine the intensity of grassland agriculture in different parts of the country.

Grassland and agriculture is a long-term program directed toward increased production from improved grasslands and more efficient use of high quality forage, rich in protein, minerals, etc. I would suggest that the use of recognized agricultural species is best,because seed supplies are much more reliable since there is a system in place in Canada to provide quality seed for agricultural production. This system is operated by the organization called The Canadian Seed Growers' Association, in conjunction with the federal government and the pedigreed seed committees in each province.

What is The Canadian Seed Growers' Association?

The Canadian Seed Growers' Association is the sole agency in Canada for pedigreeing all seed crops except potatoes and tree seeds.

The regulations and procedures for the production of pedigreed seed crops are established by committees of the Association, composed of plant breeders, research scientists, regulatory officials, seed growers, and the seed trade. Membership is open to any person, partnership. or organization wishing to produce pedigreed seed.

The affairs of the Association are conducted by a President and a Board of Directors elected by the general membership. Nine members of the Board of Directors are nominated by provincial ministers of agriculture and eleven members are nominated by active growers. The President is an active seed grower.

The Association was formed in 1904 under the sponsorship of the Canada Department of Agriculture. It has continued to cooperate with the Department, almost as a partner, to achieve its unique function. In 1923, the first non-government employee was installed as Secretary. In 1925, the office of President was filled by someone other than a federal government officer. The Association cooperates closely with all plant breeders, provincial governments, and agricultural facilities of the universities throughout the country.

The Association is a non-profit organization and is largely self-supporting; however, the Canada Department of Agriculture assists the Association financially if and when the acreage of pedigreed production falls below a specified level.

Genetic Purity

Pedigreeing of seed is designed primarily to maintain genetic purity. This is particularly important for present-day varieties that have specific factors for disease resistance and yield performance under difficult soil and climatic conditions. Along with maintaining pedigree records and establishing standards for seed production, The Canadian Seed Growers' Association encourages the development and production of superior varieties and strains, provides for the multiplication and dissemination of propagated stocks. It also plays a major role in encouraging both domestic and foreign use of pedigreed seed of superior varieties by cooperating with other agencies and governments in market development programs.

Field inspection of pedigreed seed crops is carried out by officials of the Canada Department of Agriculture. The decision to grant pedigreed status and the issuing of Crop Certificates is done by the C.S.G.A. This feature provides the necessary safeguards for an impartial appraisal of each field inspected that is recognized throughout the world.

Forage crops are normally pedigreed through three classes -- Breeder, Foundation, and Certified. All perennial crops have age-of-stand limitations which vary with the species, stating the number of years an established crop may produce a pedigreed seed crop. (Figure 1)

Why use Pedigreed Seed?

1. Genetically pure as to variety.
2. Seed with superior mechanical purity and germination.
3. Government-graded and inspected.
4. Seed produced specifically for seeding purposes.
5. Seed with proven performance.

Seed-quality standards for Pedigreed Seed are established by the Canada Seeds Act and Regulations. Before Pedigreed Seed can be sold, it must be graded in accordance with these standards and be sealed with the official tags and seals as prescribed by the above Act.

Variety Evaluation and Licensing System

A public or private plant breeder will enter his variety of any crop species into the evaluation system which is in place in all provinces. The evaluation system varies between provinces but, essentially, all federal and provincial departments and universities involved in plant breeding are included. The system involves the evaluation of variety characteristics, such as yield and disease reaction, etc., against recognized check varieties. The data accumulated in these trials is presented to Provincial Committees who assess the data and recommend that the variety under test should be re-tested, discarded, or licensed. The data, along with the provincial recommendation, is submitted to the Plant Products Division of Canada Department of Agriculture.

The data and recommendation are again assessed and, normally, the variety is licensed. When the variety is licensed, the Breeder will contact the Canadian Seed Growers' Association or the Provincial Seed Committee and request multiplication of the seed. The members of the C.S.G.A. will multiply the variety under guidelines, and the fields and seed are all inspected by Plant Products Division Inspectors. The seed is then tagged with C.S.G.A. tags and offered for sale.

This system may appear to be very cumbersome but, in actual fact, it works very well. The seed offered for sale under this system is highly respected in many parts of the world.

Selection of Species

The selection of forage or ground cover species is a decision that must be made based on a host of variables. The choice involves seed availability, soil, and climate conditions. Factors such as soil drainage, pH, persistence (winter hardiness) required, and primary use will nearly always be the principal criteria in selecting the species.

Let us look at some of the problems encountered in the establishment of a crop.

Drainage: In many cases, soil drainage will be the most critical factor, especially on areas where poor natural drainage prevails. In this case, a birdsfoot trefoil mixture would give higher yield than a mixture of alfalfa and orchard grass. Red clover is better adapted to poor drainage than alfalfa. On wet soils, alsike clover is often included with red clover to improve the stand in lower areas. Grass species, except for orchard grass, are tolerant to poor drainage. In excessively wet areas such as undrained bottom land, reed canary grass is well adapted. Tile drains or good surface drainage will be needed to maintain legumes, including birdsfoot trefoil.

Soil Acidity: At lower pH, soil reaction becomes important in alfalfa and, especially, sweet clover production. With these species, liming usually pays if the pH is 6.0 or lower. If the pH is substantially below this level, either lime the area or choose a more acid-tolerant legume. With other legumes, such as trefoil and alsike, which show less response to liming, the cost of liming is seldom warranted. Grasses do not normally show any significant yield response to pH changes.

Persistence: Once a perennial forage is established, good management in terms of fertility and weed control will help to ensure a long-lasting quality stand.

Mixtures: The greater the number of species in a mixture, the greater the opportunity for competition among species, which results in the dominance of the most competitive species and failure of the weaker ones.

Summary

1. Land that has been reclaimed will ultimately be used for food production.

2. Species used to reclaim land should be recognized agricultural species because good seed is always available for agricultural species.

3. Seed produced under the direction of C.S.G.A. and C.D.A. will be:

   - more true to variety,
   - more free of weed seeds,
   - more predictable.

4. The variety breeding,evaluation,licensing, production and recommendation systems are well established in Canada.

5. Species and variety selection is very important and must be accomplished after all variables have been considered.

PEDIGREED GRASS SEED PRODUCTION

ndation or Registered
d produced by a member
the Canadian Seed Growers
ociation, graded sealed
tagged

chased to produce a
igreed seed crop

wn with clean
ipment
wn on land that has not
duced a crop of the same
d in preceding three years
op isolated by 165 feet
m other plants of the same
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wer completes an Application
Crop Inspection and sends
to the C.S.G.A. Ottawa
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.G.A. arranges for crop
pection with the Plant
ducts Division of
riculture Canada

crop is inspected by
officer of the P.P.D.
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Report of Crop Inspection
sent to the C.S.G.A. where
is determined if the crop
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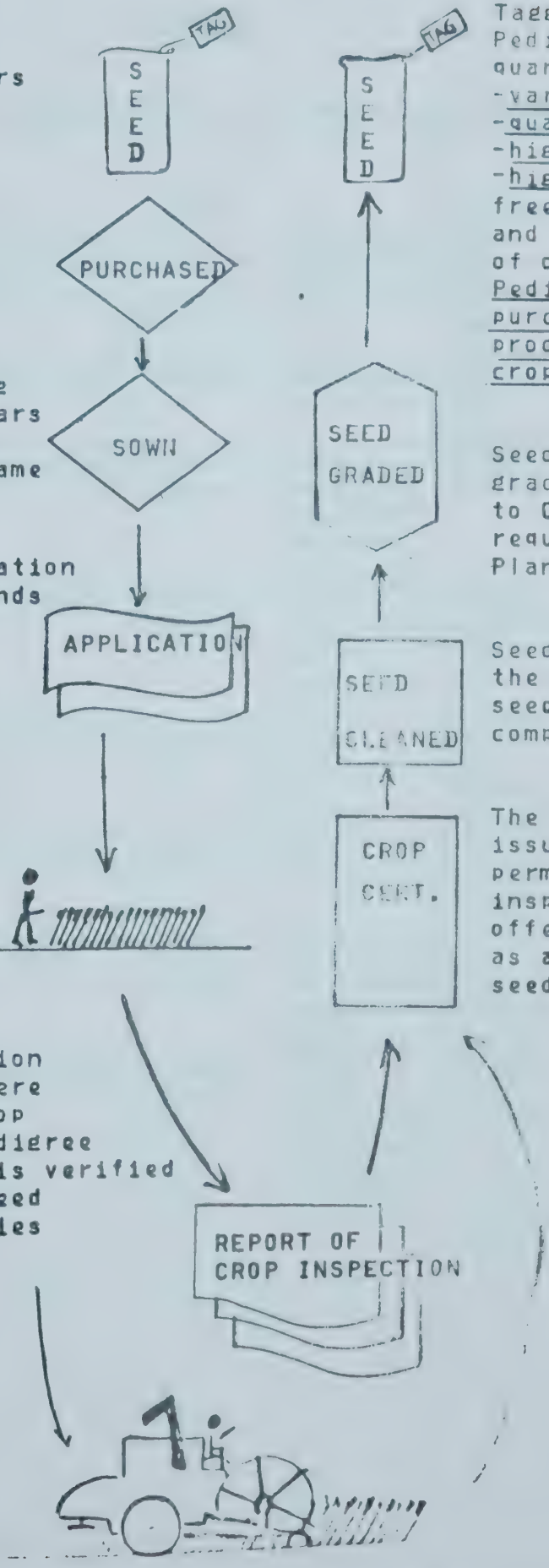

Tagged and sealed Pedigreed seed is guaranteed
-varietal purity
-quality seed
-high germination
-high degree of freedom from weed seeds and undesirable seed of other crops.
Pedigreed seed is purchased for the production of better crops

Seed is inspected, graded and sealed to Canada Seeds Act requirements by the Plant Products Div.

Seed is cleaned by the grower or a seed processing company

The Crop Certificate issued by the CSGA permits seed from the inspected crop to be offered for sealing as a class of pedigreed seed

Crop is harvested with clean equipment and stored in clean bins until seed is processed

APPENDIX 1

TABLE OF VARIOUS SPECIES & CHARACTERISTICS *(THAT MAY BE USED TO SELECT AN ADAPTABLE CROP)*

ECIES	pH RANGE FOR OPTIMUM GROWTH	REQUIRED DRAINAGE	PERSISTENCE	PRIMARY USE	ADVANTAGES	CAUTION AREAS	CULTURAL NOTES	VARIETIES
alfa	6.5-8.0	Excellent	2-4 years	Stored forage	High yield	Bloat; Poor persistence	Livestock feed	Iroquois Vernal
foil	5.5-7.5	Poor to excellent	Long term	Pasture	Excellent persistence	Difficult to establish	Livestock feed and cover crop	Leo Empire
ver	6.0-7.5	Moderately poor to excellent	1-3 years	Stored forage	Easy to establish; Tolerates wet and acid soil	Short lived	Livestock feed	Ottawa Dollard
ike ver	5.5-7.5	Poor to excellent	2-3 years	Stored forage	Tolerant to poor drainage and quite acid soil	Lack of persistence; Will reseed itself	Drainage tolerant	Aurora Dawn
te ver ld te)	6.0-7.5	Moderately good to excellent	Long term	Pasture	Self-maintaining	Lack of yield; Dries up in summer	Wild in many areas	Common
te ver dino)	6.0-7.5	Moderately good to excellent	1-2 years	Pasture	Fast regrowth	Lack of persistence; Required moisture	Quick regrowth	Merit
t er	6.5-8.0	Moderately poor	2 years	Green manure	Excellent soil builder; Opens up soil's oil	Low palatability	Usually seeded alone	Polara Yukon
wn ch	6 or above	Well drained soil	Excellent	Ground cover	Ground cover in mine spoil areas and highways	Establishment problems	Poor seed production	Penngift

Cont'd ... OVER

APPENDIX 1
(Cont'd)

TABLE OF VARIOUS SPECIES & CHARACTERISTICS *(THAT MAY BE USED TO SELECT AN ADAPTABLE CROP)*

ECIES	pH RANGE FOR OPTIMUM GROWTH	REQUIRED DRAINAGE	PERSISTENCE	PRIMARY USE	ADVANTAGES	CAUTION AREAS	CULTURAL NOTES	VARIETIES
ome	Not pH sensitive	Moderately poor to excellent	Excellent	Stored feed	Early spring growth	Difficult to establish	Responds well to N	Baylor Saratoga
othy	Not pH sensitive	Poor to excellent	Excellent	Stored feed	Easy to establish	Slow recovery after cutting	Responds to N	Champ Itasca
ed ry	Not pH sensitive	Very poor to excellent	Excellent	Low land	Does well under poor and on dry land	Heavy growth	Responds to high fertility	Frontier Rise
hard ss	Not pH sensitive	Moderately good to excellent	Good	Stored feed	Drought resistant	Less winter hardy than other grasses	Responds well to N	Hallmark Kay
sted at sses	Does not tolerate alkali soils	Good to excellent	Excellent	Reseeding of range-land	Wind and water erosion; Drought resistant	Will not persist on flooded areas	Adapted to Western Canada	Summit Nordan
egrass ada	Not pH sensitive	Fair to well drained	Excellent	Ground cover	Drought resistant; Goes dormant	Needs open area	Responds to irrigation and N	Canon
op	Grows on very acid soil	Poor	Excellent	Ground cover	Low fertility	Will not live in very dry areas	Creeping and upright	Common
dow cues	Not pH sensitive	Poor to excellent	Excellent	Pasture	Good on wet land	Susceptible to leaf rust	Responds to fertilizer	Ensign Trader
eping cues	Not pH sensitive	Poor to excellent	Excellent	Turf and soil con-servation	Useful on dry, sandy and shady areas	Strains vary in spreading habit	Spreads by rhizomes and seed	Boreal
grass ennial	Not pH sensitive	Moderately good to excellent	3-4 years	Soil con-servation and turf	Rapid seedling growth	Low temp-erature; Drought; Poor fertility	Responds to high fertility	Norlea

THE APPLICATION OF PROCESSED ORGANIC WASTE TO ACID MINE TAILINGS

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The city of Sudbury has solved the problem of discarding its processed organic waste (sewage sludge), that results from secondary treatment of sewage, by spreading the very liquid waste (1½% solids) onto the International Nickel Company's Copper Cliff tailings.

A problem exists, however, in that sewage treatment tends to concentrate toxic ions such as nickel and copper and these then constitute a potential hazard to plant growth and as a contaminent in seepage water. Although the raw sewage has been digested during treatment, the bacterial count is still fairly high and this adds further to the possibility of contamination.

The present three-year investigation which is funded by the Ministry of the Environment (Ontario) was initiated in September 1973 and has three aims:

1) the monitoring of seepage water quality (bacteria and heavy metals),
2) the role of sewage sludge as a fertilizer and soil ameliorant,
3) the role of the tailings as a filter bed to bacteria and heavy metals.

The monthly sampling of seepage water during the frost-free season (May to November) has shown no definable trend in heavy metal levels that could be attributed to the application of sewage sludge, whereas coliform bacteria were found several times during Summer 1975. The source is not presently known.

Measured quantities of sludge were applied to two sample areas of the tailings several times each season; application frequency being controlled by the moisture content of the tailings. Samples of sludge, tailings and vegetation were taken regularly during each frost-free season for subsequent analysis.

Laboratory studies with undisturbed tailings cores showed that percolation was severely impeded following three or four applications of sludge but that simulated 'discing' restored percolation to former levels. At the same time the increase in organic matter improved the water-holding capacity of the soil.

The analysis of the heavy metals in the sewage sludge/tailings/plant

system has been slow to date and little quantitative data are available. There are, however, two subjective conclusions that may be made. No serious heavy metal toxicity symptoms have been noted, and there was a very marked visible change in the vigour of the tailings grasses at the end of the 1975 field season. The lack of toxicity indicates that the organic matter is tying up heavy metals over and above changes that occur in texture and water-holding capacity. Furthermore, whereas the nitrogen is present in minimal quantities, it is present in a very favourable form for plant growth and is having a maximal effect as a fertilizer.

The work remaining consists of further percolation tests through undisturbed tailings cores to determine the efficacy of tailings as a bacterial filter, and the completion of heavy metal analyses by atomic absorption spectrophotometry.

It is hoped that the results of this study will help establish guidelines for management of tailings to which sewage sludge has been applied.

QUESTIONS AND ANSWERS ABOUT PRILLCOTE SEED

G. Eros,
OSECO Limited
Brampton, Ontario

1. Q. WHAT IS PRILLCOTE SEED?

   A. Prillcoting is a unique process which coats each seed with a combination of the additives needed for improved germination and seedling establishment.

2. Q. WHAT DOES THE COAT CONTAIN?

   A. There is no universal coat. It must be tailored to the type of seed, the soil and the growing conditions in each area. Generally, however, the legume coats contain rhizobia, a nutrient for the rhizobia, trace elements and fertilizers, such as phosphorus and lime. For grasses, the coat is basically a nutrient coat to promote seedling establishment.

3. Q. WHAT IS THE ADVANTAGE OF PRILLCOTE SEED OVER BARE SEED?

   A. Prillcoted seed contains highly concentrated rhizobia and nutrients which, due to their strategic placement surrounding the seed, have a multiplier effect in the soil. Also the viability of the rhizobia is greatly prolonged by the coating and is, therefore, much more effective than present methods used. The coating also improves the water relationships of the seed in the soil, and further aids germination particularly under stress conditions. The coating also protects the seed from diseases, insects and birds.

4. Q. WHAT SEEDING RATE SHOULD I USE FOR PRILLCOTE SEED?

   A. Use the same weight of Prillcote seed per acre as you would use for bare seed.

5. Q. HOW MUCH ACTUAL SEED IS IN A POUND OF PRILLCOTE SEED?

   A. This varies with the species; but generally for legumes it is two/thirds seed to one-third coat, and for grasses it is 50 per cent seed and 50 per cent coating material.

6. Q. HOW MUCH DOES PRILLCOTE SEED COST?

   A. The price per pound of coated weight is approximately the same as bare seed, but since the seeding rate is the same the cost per acre is also identical with bare seed. Therefore, with the improved rate of establishment and survival, the actual cost per established plant is significantly less.

7. Q. WHERE SHOULD PRILLCOTE SEED BE USED?

   A. Prillcote seed will show benefits under any application where bare seed is now used, even on the best arable soils. However, it is especially advantageous when seeding under unfavourable or stress conditions such as:

   Roughland pasture renovation
   Revegetation projects
   Mine and quarry seedings
   Surface overseedings
   Range reseedings
   Right-of-way seedings.

8. Q. WILL PRILLCOTE SEED CARRY?

   A. The shelf life of Prillcote seed is unchanged from bare seed. The only concern is the rhizobia which should survive under cool dry conditions such as we have in Eastern Canada for a twelve to eighteen month period. However, we suggest sowing within six months.

9. Q. WHEN WAS PRILLCOTE SEED FIRST INTRODUCED?

   A. Trials were started by the University of Guelph in 1969 and the first commercial distribution was in spring, 1975 by Oseco Limited of Brampton, Ontario.

10. Q. WHAT ARE THE RESULTS SO FAR?

    A. The work carried on by the University of Guelph is summarized in the publication of ARDA Project #85045 "An Assessment of Shallow Soil Pastures in Ontario", which comments in part as follows:

10. A. (continued)

> "Seeds were sown on the surface and at 6 millimeters depth in the Guelph loam soil. There were ten seeds for each of four replicas. At both seeding depths, germination was more rapid and the percentage of seeds establishing was greater with pelletted than non-pelletted seed. Seedling vigor of pelletted seed was also greater than non-pelletted seeds in the surface sown treatment."

Comments from farmers and extension workers who sowed Prillcote seed in the spring of 1975 range all the way from:

> "Saw no difference between Prillcote seed and bare seed".

to: "Our test site was very dry this year and Prillcoted seed was the only thing that grew".

11. Q. DO I NEED TO CHANGE MY SEEDER CALIBRATION WITH PRILLCOTED SEED?

A. Since Prillcote increases the seed size by about 15% - 20%, the seeder calibration should, therefore, be opened by about 20%.

12. Q. CAN I USE PRILLCOTE SEED IN A HYDRO SEEDER?

A. Yes. However, as with bare seed, the Prillcoted seed should be added to the tank last and should not be allowed to stay in the tank for any prolonged period of time,as the coating will wash off in time under agitation. (Special harder coatings for this application will be available in the future).

13. Q. DOES THE LIME IN THE LEGUME PRILLCOTE AID THE ESTABLISHMENT OF ALFALFA IN ACID SOILS?

A. Yes - since alfalfa once established will survive on soils normally too acid for alfalfa establishment. A New Zealand study has shown that ten pounds of lime on the seed coat is equivalent to one ton of lime broadcast per acre for nodulation response.

14. Q. HOW IS PRILLCOTE SEED ANALYSED?

A. For germination, it is tested the same as bare seed. For purity, the coating must be washed off, which can be done quite simply in the laboratory.

15. Q. ARE THERE OTHER SEED COATING PROCESSES AVAILABLE BESIDES PRILLCOTE?

A. Yes, several companies are doing a pre-inoculation coating and a lime coating. However, only Prillcote combines all the necessary rhizobial and nutrient additives necessary for improved seedling establishment.

16. Q. WHY IS INOCULATION SO IMPORTANT ON SOILS WHERE LEGUMES HAVE BEEN GROWN BEFORE?

A. Recent research has shown that rhizobial bacteria can be quite specific not only to species but in some cases to the variety used. Also, native rhizobia in the soil can be ineffective, antagonistic or even parasitic. The inoculant used in Prillcote seed is of the correct strain and is highly concentrated and, due to its strategic placement, it has the best chance of infecting the root nodule with the correct strain of bacteria, which can result in vastly improved nitrogen fixation.

17. Q. HOW MUCH NITROGEN WILL WELL-INOCULATED LEGUMES ADD TO MY SOIL EACH YEAR?

A. Various studies,summarized by Al Jensen of the North Dakota Extension Service, report that legumes can fix up to 200 pounds of nitrogen per acre per year.

18. Q. CAN PRILLCOTE SEED BE MIXED WITH FERTILIZER?

A. Yes, since the Prillcoting insulates the seed from the fertilizer they can be sown together without harm.

19. Q. WHAT KINDS OF PRILLCOTED SEED WILL BE AVAILABLE FROM RETAILERS IN EASTERN CANADA FOR SPRING 1976 SEEDING?

A. At present, Oseco Limited are planning to make available the following kinds and varieties:

Anchor Alfalfa	Leo Birdsfoot Trefoil	Toro Timothy
Tital Alfalfa	Empire Birdsfoot Trefoil	Baylor Bromegrass
WL215 Alfalfa	Penngift Crownvetch	Tetra Alsike

Q. CAN I GET OTHER KINDS OF SEEDS PRILLCOTED?

A. Requirements for other seeds in 1976 will be filled provided sufficient quantities can be generated to meet the minimum-batch requirements of the Prillcoting plant. These are approximately one ton per batch. Trial quantities can also be coated for research purposes in a laboratory unit. Present plans call for the construction of a Prillcoting plant in southern Ontario in 1976, so that by the spring of 1977 a full range of Prillcoted seed can then be offered.

GROWTH OF PLANT COVER ON AN ELECTRIC POWER UNDERGROUND TRANSMISSION PROTOTYPE: THE EFFECTS OF THERMAL STRESS

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Biologist
Research Division
Ontario Hydro

SUMMARY

Heat is the major stress factor on plant growth covering an underground electric transmission system. These effects were examined during two growing seasons on an Ontario Hydro air-insulated underground transmission prototype (DAMUT) with test thermal load of 210 watts per metre of duct length and soil root-zone maximum temperatures of approximately 35°C; winter temperature did not fall below 0°C. Fresh and dry weight and plant height data indicate that turf growth was stimulated over the heated ducts in early spring and late fall while shrub growth remained unchanged compared to unheated controls. Yields of agronomic crop species were reduced by approximately 40 to 50% compared to controls, indicating that normal agricultural productivity could not be achieved on such transmission rights-of-way. Germination of spring-sowed crops was reduced, probably due to soil drying and not a direct thermal effect. No major nutrient or pH changes were observed in the heated soil over a two-year period. It thus appears that suitable plant cover consisting of turf, shrubs and selected agronomic crops could be established over electric power transmission systems having thermal losses up to 210 watts per metre of duct buried at 1.1 metre depth.

EXPERIMENTAL WORK

Preliminary studies of the effects of soil heating on plant growth by an underground electric power transmission prototype are reported in this paper. An air-insulated underground transmission model, DAMUT, was designed by Ontario Hydro's Research Division to carry very high electrical loads, 230 000 volts at 3 000 amperes. The thermal behaviour of such a design was examined for 2 years under field conditions at Kleinburg, north of Toronto. Air-insulated underground systems, though presently economically less attractive than overhead lines, would provide alternative methods of moving large blocks of power, reduce right-of-way size and improve visual impact.

Heat losses from the DAMUT model or other buried transmission systems of high ampacity cause soil warming which may affect plant and soil microbial life. The quality, growth and yield of agronomic and horticultural plants common to southern Ontario Hydro rights-of-way were measured during the 1974 and 1975 growing seasons for DAMUT-heated and control soils at Kleinburg. The data show that cover-crops may be established on warmed soils with summer temperature maxima of approximately 35°C which is 10 to 15°C above ambient.

Figure 1 outlines a vertical cross-section of a 2-duct DAMUT installation designed to simulate a multi-duct system of infinite length by insulating one sidewall and each endwall. Each duct of 9 metre length was buried to a depth of 1.1 metres in a 9 x 10 metre plot. An additional 9 x 11 metre area of native clay soil provided an unheated control plot for the vegetation studies. The ducts rested on a bed of sand covered with limestone screenings to provide optimal thermal conductivity and topped with 15 cm of native clay topsoil similar to the control area. This was considered the minimum depth of soil necessary to support herbaceous plant growth. Flooding of the ducts during heavy precipitation was prevented by sump pump drainage which may have had a cooling effect on duct operation. The ducts were loaded with resistive heaters at 210 watts per metre of duct length to simulate a 230 kV, 3 000 amp transmission line. Duct and control area temperatures were monitored daily by over 100 thermocouples placed at various soil depths and above ground. Figure 1 also shows the locations of thermocouples used to obtain data for plotting temperature profiles for the top surface of the inner duct (1.1 metre depth), the root-zone soil at 15 cm depth and ambient air 0.5 m above grade.

Temperature profiles for the past year, outlined in Figure 2, show the influence of high fluctuations in ambient air temperatures in modifying the soil root-zone profile, given rather smooth changes in temperature at the inner duct surface. The two most important features of the root-zone temperature profile are the maxima of approximately 35°C, achieved during the months of July and August, and the minima of about 7°C, reached during the the winter. At the soil surface where temperatures were cooler snow cover rarely remained for more than 2 to 3 days throughout the entire winter period.

During the initial 9 months, January 1974 to September 1974, operation of the ducts' similar temperature profiles were obtained; summer maxima reached 35°C in July and August, and winter temperatures did not fall below 0°C. The temperatures during both growing seasons in the root-zone above the outer duct were approximately 1 to 2°C cooler than for the inner duct.

Figure 3 compares the temperature profiles for soil at 15 cm depth for both inner duct and unheated control areas. At this depth, the duct raised the soil temperature throughout the year from 10 to 15°C above ambient. It is the effects of this temperature rise which are examined in the following vegetation studies.

The common agronomic crops, turf grasses, shrubs and vines tested for capability of growing in the warmed duct soils are listed in Table 1. The agronomic species and creeping red fescue were seeded in rows on June 7, 1974 except for wheat and crested wheatgrass which were sown September 26, 1974 and May 21, 1975, respectively. Shrubs, vines and bluegrass sod mixtures were transplanted on November 29, 1973. Agronomic crops were fertilized at time of seeding with 5-20-20 at approximately 3.9 kg/100 m^2(8 lbs/1 000 ft^2), and turf grasses with 7-14-7 at 2.9 kg/100 m^2(6 lbs/1 000 ft^2). Turf grasses were refertilized in the spring of 1974 and 1975 with 10-6-4, containing 60% milorganite, at 9.7 kg/100 m^2(20 lbs/1 000 ft^2).

Throughout each growing season the overall quality of plant growth was assessed by visually rating symptoms attributable to thermal or moisture stress. This included foliar chlorosis, discoloration, necrosis and wilting. The quality ratings* for turf grasses grown during May to September 1975 are shown in Figure 4. The condition of all grasses was noticeably lower in the duct compared to control areas, with a sharp decline of all turf in early July. This corresponded to lack of any rainfall for the previous 3-week period, based on meteorological records for Toronto International Airport located 20 km SSE of Kleinburg. Although turf quality over the ducts was lower throughout the normal growing season, yield for 1974, shown later (Table 5), was higher in duct than control areas due to an extension of the growing period into early spring and late fall.

The quality of agronomic crops is summarized in Figure 5. These crops did not show as severe a decline in quality in early July as did the turf grasses. In both duct and control areas alfalfa and red clover appeared most sensitive to thermal and moisture stresses which in clover was accompanied by premature leaf senescence and blackened necrosis, especially in the duct area. Generally the appearance of the agronomic species remained similar in duct and control areas except for reed canary grass which displayed considerably lower quality throughout most of the growing season. Newly seeded crested wheatgrass displayed poor germination and lower vigor throughout the growing season. Similar effects were observed for the remaining agronomic species during their first year of growth (1974 data not shown).

Rather interestingly, the drought-resistant shrubs and vines listed in Table 1 did not show any noticeable difference in appearance between duct and control areas. Though growth data was not obtained, due to the very small number of specimens grown in the test plot, there did not visually appear to be any reduction of growth over the heated duct.

Though the appearance of agronomic crops was not very different between duct and control areas, yield data, based on shoot and root lengths, fresh weights and dry weights showed declines in both 1974--Table 2, and 1975 - Table 3. These yield reductions ranged generally from a few per cent up to nearly 100 per cent in duct versus control areas. Practically, shoot fresh and dry weights are most important and these ranged from 18 to 93% reductions in 1974, and from 1 to 57% in 1975, except for crown vetch and a second crop (August 5 - September 22, 1975) of red clover. Most of the growth of the latter occurred during September when temperature may have had a beneficial effect. At this time root-zone soil temperatures averaged about 25°C. Root/shoot length ratios increased over the duct area, due

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* - Visual estimates of foliar quality: 10 = excellent;
5 = intermediate;
0 = dead.

presumably to the effects of moisture stress in reducing shoot elongation. Absolute root lengths were less seriously affected by the warmed soil, contrary to what was expected.

The yield data just presented was based on the sampling and measurement of 10 plants at each of 2 sites in the duct and control areas. These figures, therefore, do not include any measurement of reduction in crop density which visual inspection indicates was reduced due to decreased germination rates in the duct area.

Yield of two grains, oats and barley, are shown in Table 4. Reductions occurred in lengths and fresh weights of roots and shoots and, most important, in seed number and seed fresh weight. The seed yield for both oats and barley declined by 26 to 55% in duct over control areas.

In contrast to agronomic crops, soil heating appeared to have a beneficial effect on the yield of turf grasses by extending the normal growing season into early spring and late fall. Based on height of clippings obtained May 4, July 4 and September 18, 1974 duct area turf height in spring and fall was more than double that of controls, Table 5. This accounted for approximately a 50% increase in the total turf cut from the duct area during the growing season. Based on visual appearance, this effect was not observed for other plants due in part to their susceptibility to frost injury outside the normal growing season. The recovery of turf in the fall indicates that significant root injury has not resulted from exposure to mid-summer temperatures up to 35°C.

Data shown in Table 6 indicate that the limestone screenings, 15-45 cm depth, of the duct area were uniformly low in moisture content both in the spring and fall. Only the clay topsoil, 0-15 cm depth, appears to contain sufficient moisture to support plant growth (moisture release curves not determined). No irrigation was used since it was an objective to determine the duct thermal behaviour under normal weather conditions.

It was expected that the limestone screenings of the duct area may have raised topsoil pH and calcium concentrations, thereby retarding plant growth and interfering with estimates of thermal effects on plant development. It was observed that there was a sharp demarcation in plant height between duct and control areas which did not correspond to the temperature gradient, but rather to the boundary line between areas with and without limestone screenings. After nearly 2 years of duct operation (January 1974 to October 1975) no significant changes were observed in duct soil pH and in levels of available soil calcium compared to control values. The concentrations of phosphorus, potassium and magnesium were also unchanged, Table 7. It is concluded that the reduction of plant growth over the ducts was due to a combination of thermal and moisture stresses. While there is insufficient evidence to establish the relative importance of each of these stresses, it is suggested that yield reduction was caused chiefly by thermally induced moisture stress. It is expected that temperatures in the range of 40 to 50°C are required before plant metabolism is seriously interrupted.

LIST OF PLANTS GROWN IN DAMUT VEGETATION PLOT

COMMON NAME	BIOLOGICAL NAME	VARIETY
AGROMONIC CROPS		
ALFALFA	MEDICAGO SATIVA L	SARANAC
BIRDSFOOT TREFOIL	LOTUS CORNICULATUS L	EMPIRE
CROWN VETCH	CORONILLA VARIA L	
RED CLOVER	TRIFOLIUM PRATENSE L	ONTARIO DOUBLE-CUT
TALL FESCUE	FESTUCA ARUNDINACEA	
REED CANARY GRASS	PHALARIS ARUNDINACEA L	FRONTIER
CRESTED WHEATGRASS	AGROPYRON CRISTATUM	
WHEAT	TRITICUM VULGARE L	YORKSTAR - WINTER VARIETY
OATS	AVENA SATIVA L	RODNEY
BARLEY	HORDEUM VULGARE L	FERGUS
TURF GRASSES		
KENTUCKY BLUEGRASS (SOD)	POA PRATENSIS L	KENTUCKY (>90%) + CREEPING RED FESCUE MIXTURES
KENTUCKY BLUEGRASS (SOD)	POA PRATENSIS	KENTUCKY (>90%) + MERION MIXTURES
CREEPING RED FESCUE	FESTUCA RUBRA L	
SHRUBS AND VINES		
WINTERCREEPER	EUONYMOUS FORTUNEI	COLORATA
VIRGINIA CREEPER	PARTHENOCISSUS QUINQUEFOLIA	ENGELMANII
CHINESE MATRIMONY VINE	LYCIUM CHINENSE	
BUSH CINQUEFOIL	POTENTILLA FRUCTICOSA	FARRERI (GOLD DROP)

TABLE 1

TABLE 2

1974 YIELD OF AGRONOMIC CROPS

CROP		LENGTH (cm) SHOOT	LENGTH (cm) ROOT	FRESH WEIGHT (g) SHOOT	FRESH WEIGHT (g) ROOT	LENGTH ROOT/SHOOT
ALFALFA	CONTROL	12.5	10.0	0.08	0.11	0.81
	DUCT	7.5	11.0	0.07	0.09	1.48
	% CHANGE	-40	+10	-13	-18	+82
BIRDSFOOT TREFOIL	CONTROL	14.0	11.0	0.67	0.19	0.79
	DUCT	10.5	9.5	0.43	0.10	0.91
	% CHANGE	-25	-14	-36	-90	+15
CROWN VETCH	CONTROL	14.0	19.0	0.44	0.32	1.36
	DUCT	6.0	10.5	0.12	0.09	1.75
	% CHANGE	-57	-45	-73	-72	+29
RED CLOVER	CONTROL	14.5	7.0	0.76	0.25	0.48
	DUCT	6.5	7.0	0.25	0.08	1.07
	% CHANGE	-55	0	-67	-68	+123
TALL FESCUE	CONTROL	21.5	5.0	0.39	0.15	0.24
	DUCT	18.5	3.5	0.10	0.01	0.21
	% CHANGE	-14	-30	-75	-93	-13
REED CANARY GRASS	CONTROL	27.0	4.5	0.29	0.20	0.17
	DUCT	17.5	3.5	0.22	0.15	0.21
	% CHANGE	-35	-22	-24	-25	+23

TABLE 3

1975 YIELD OF AGRONOMIC CROPS

CROP		LENGTH (cm)		FRESH WT(g)		DRY WT(g)		LENGTH
		SHOOT	ROOT	SHOOT	ROOT	SHOOT	ROOT	ROOT/SHOOT
ALFALFA	CONTROL	65.0	15.5	10.0	6.1	2.4	1.5	0.24
	DUCT	55.0	14.5	9.9	5.5	2.5	1.4	0.27
	% CHANGE	-15	-6	-1	-10	+4	-6	+13
BIRDSFOOT TREFOIL	CONTROL	31.8	19.2	7.75	3.09	2.00	0.84	0.61
	DUCT	26.2	18.4	3.35	1.62	0.79	0.37	0.71
	% CHANGE	-18	-4	-57	-48	-60	-56	+16
CROWN VETCH	CONTROL	22.9	20.5	2.03	1.83	0.42	0.54	0.90
	DUCT	17.7	21.8	2.85	1.85	0.59	0.50	1.25
	% CHANGE	-23	+6	+40	+1	+40	-7	+39
RED CLOVER (2ND CROP)	CONTROL	23.1	16.2	5.20	2.24	0.88	0.47	0.71
	DUCT	23.7	17.2	6.03	2.73	1.04	0.64	0.73
	% CHANGE	+3	+6	+16	+22	+18	+36	+3
TALL FESCUE	CONTROL	54.5	10.0	2.73	0.51	0.61	0.11	0.19
	DUCT	50.5	8.0	2.00	0.22	0.44	0.04	0.16
	% CHANGE	-7	-20	-27	-57	-28	-64	-16
REED CANARY GRASS	CONTROL	46.1	20.3	7.14	8.49	2.25	1.73	0.44
	DUCT	36.2	16.7	3.68	4.40	1.34	0.86	0.47
	% CHANGE	-21	-17	-48	-48	-40	-50	+7

TABLE 4
TABLE 5
TABLE 6

TABLE 4

1974 YIELD OF AGRONOMIC CROPS - GRAINS

CROP		LENGTH (cm) SHOOT	LENGTH (cm) ROOT	FRESH WT (g) SHOOT	FRESH WT (g) ROOT	AVG NO SEEDS/PLANT	SEED FRESH WT PER PLANT (g)
BARLEY	CONTROL	56.4	7.2	1.69	0.26	19.0	0.94
	DUCT	48.0	5.7	1.20	0.26	14.0	0.59
	% CHANGE	-15	-21	-29	0	-26	-37
OATS	CONTROL	74.9	14.9	3.06	0.51	24.0	1.75
	DUCT	43.1	10.5	1.02	0.18	12.0	0.79
	% CHANGE	-42	-30	-67	-65	-50	-55

TABLE 5

YIELD OF TURF GRASSES

GRASS MIXTURE		AVERAGE HEIGHT (cm) HARVEST NO.1	HARVEST NO.2	HARVEST NO.3	TOTAL
KENTUCKY BLUEGRASS AND MERION BLUEGRASS	CONTROL	1.6	8.5	1.8	11.0
	DUCT	6.0	9.9	3.4	19.3
KENTUCKY BLUEGRASS AND CREEPING RED FESCUE	CONTROL	1.7	10.0	1.0	12.7
	DUCT	4.3	9.2	3.8	17.3

TABLE 6

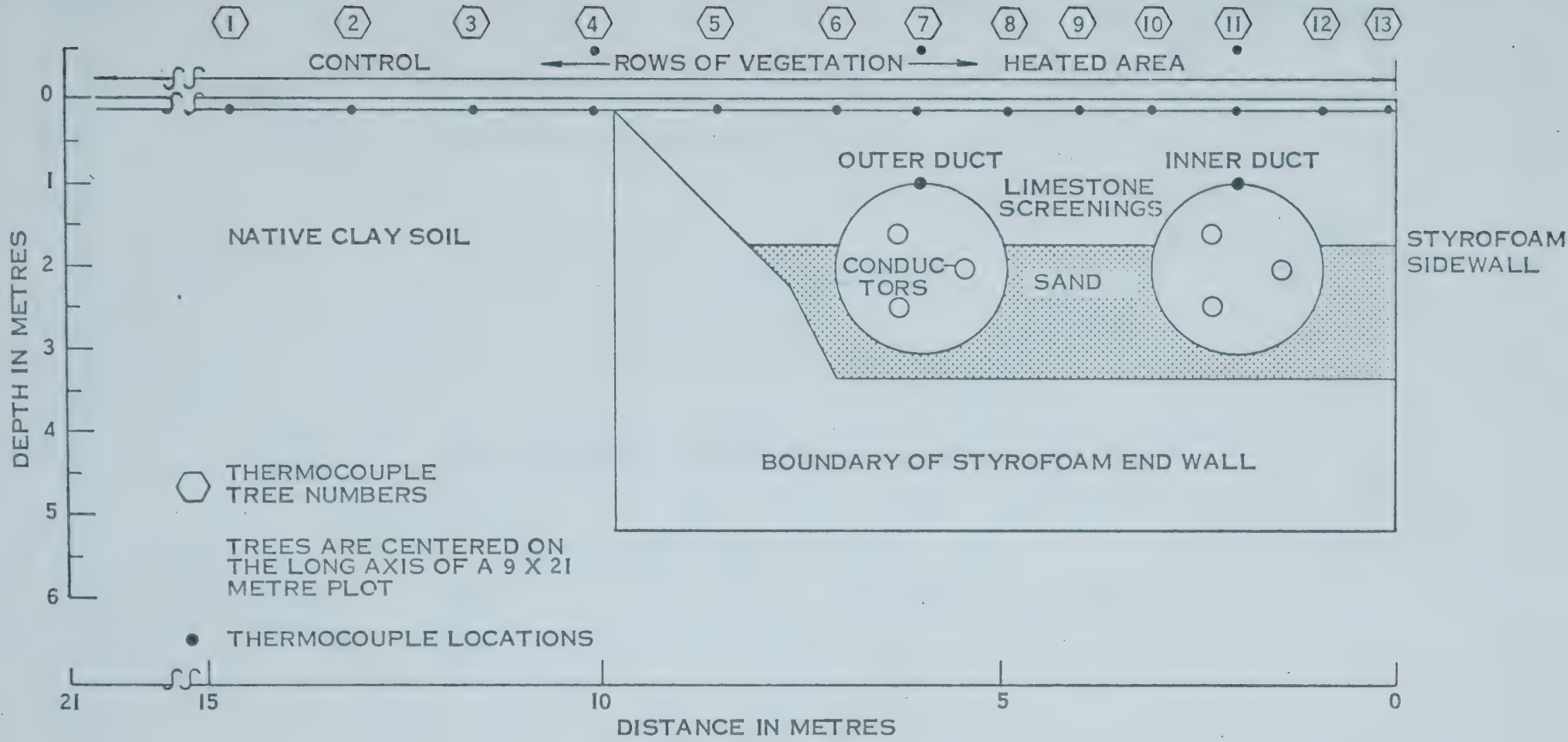
MOISTURE CONTENT OF HEATED AND CONTROL SOILS

DATE	DEPTH (cm)	PER CENT MOISTURE ON DRY WEIGHT BASIS THERMOCOUPLE TREE NO CONTROL	5	7	9	11
MAY 13, 1975	0 — 15	21.3	14.4	12.4	13.6	15.6
	15 — 45	21.6	5.3	4.7	4.6	4.6
AUG 1, 1975	0 — 15	—	11.4	14.1	12.6	11.1
	15 — 45	11.5	2.2	1.6	2.1	1.7

TABLE 7

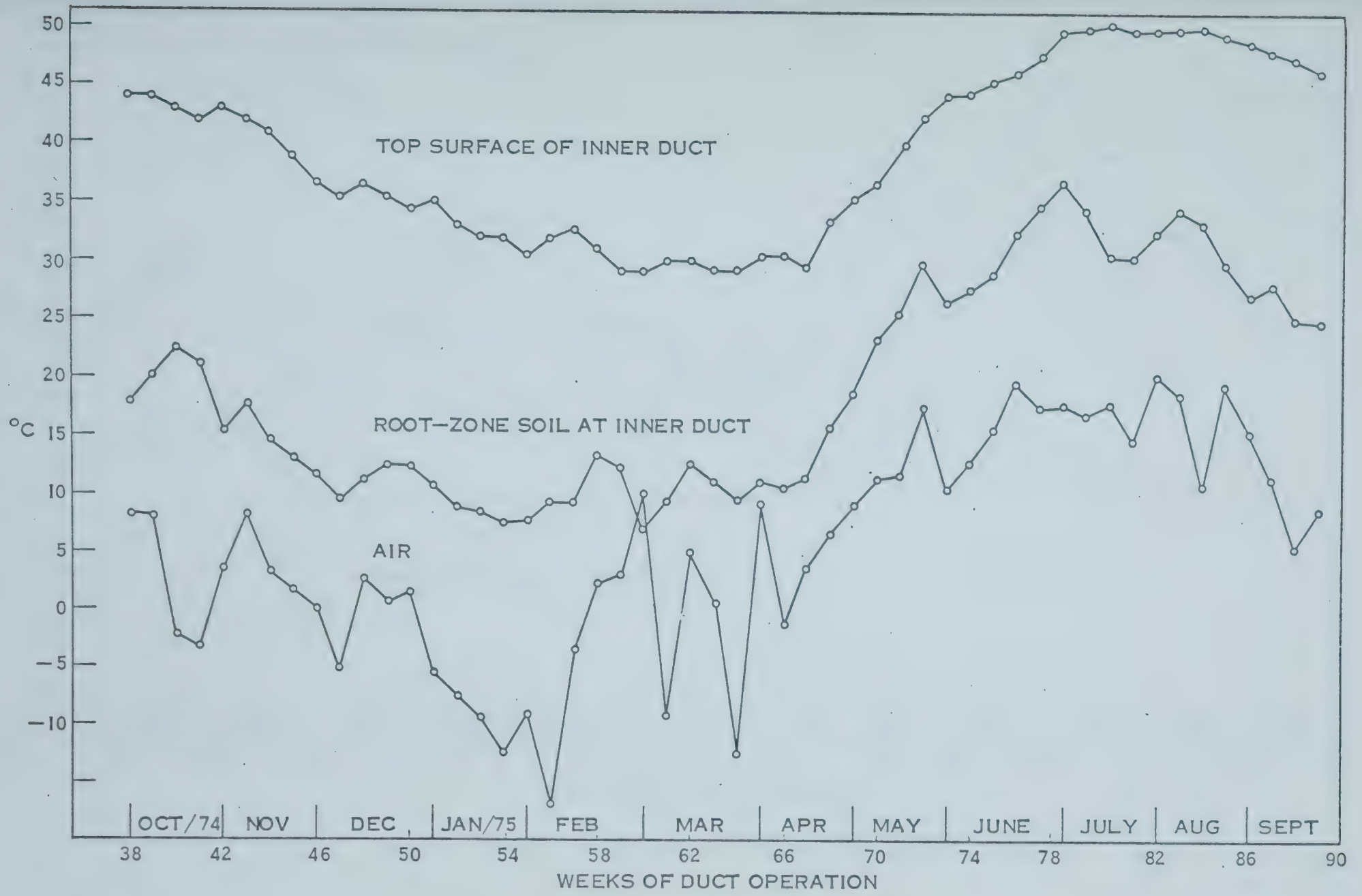
SOIL NUTRIENT LEVELS OF
HEATED DUCT AND CONTROL AREAS

DATE	AREA	pH	NUTRIENT CONCENTRATION (ppm)			
			P	K	Mg	Ca
OCT.3/74	CONTROL	7.2	8	160	236	5100
OCT.3/74	DUCT	7.3	9	150	252	6700
OCT.1/75	CONTROL	7.7	9	116	212	5250
OCT.1/75	DUCT	7.8	9	122	248	6750



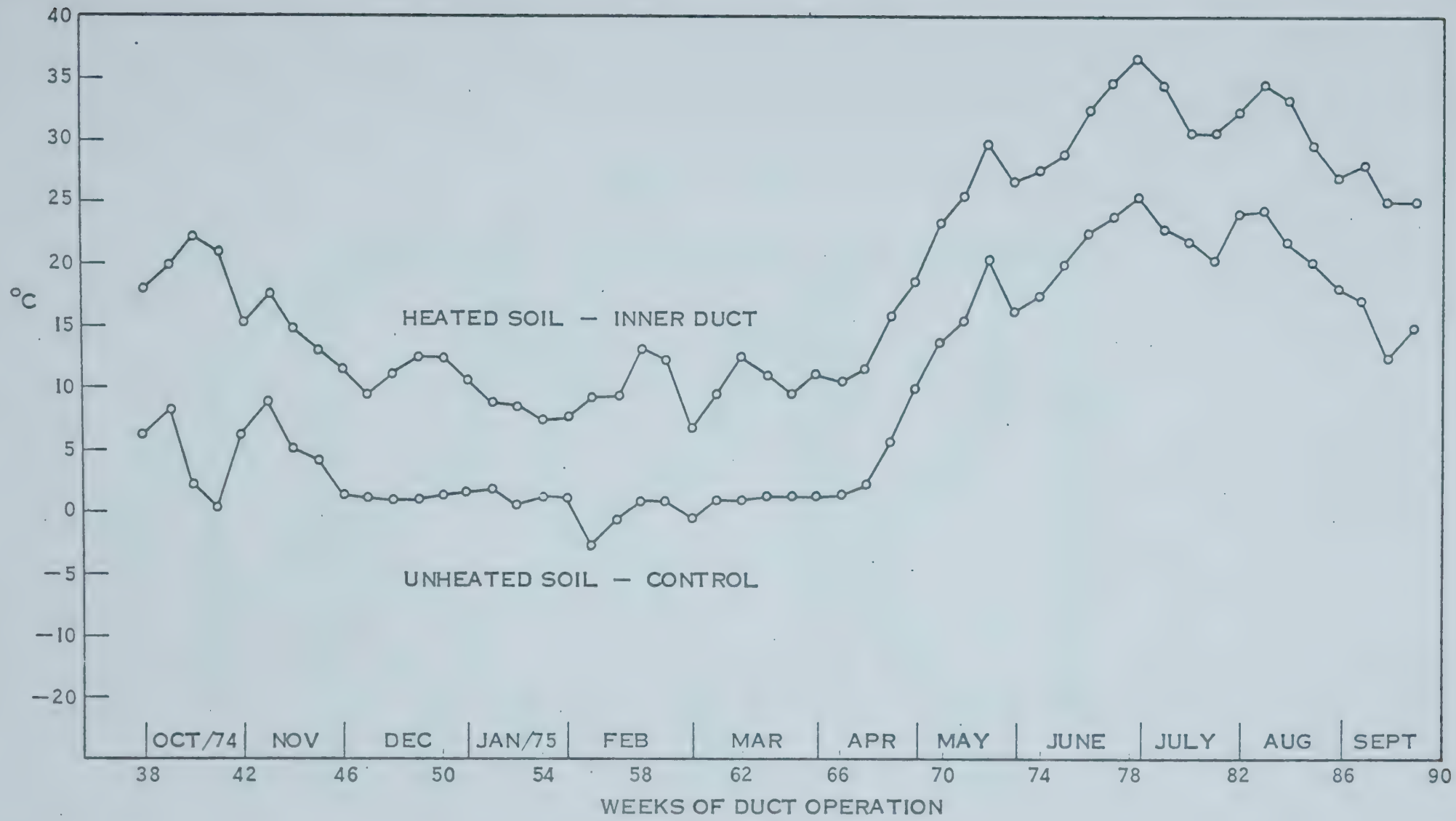
DAMUT PROTOTYPE: 2—DUCT SYSTEM WITH VEGETATION PLOT

Figure 1



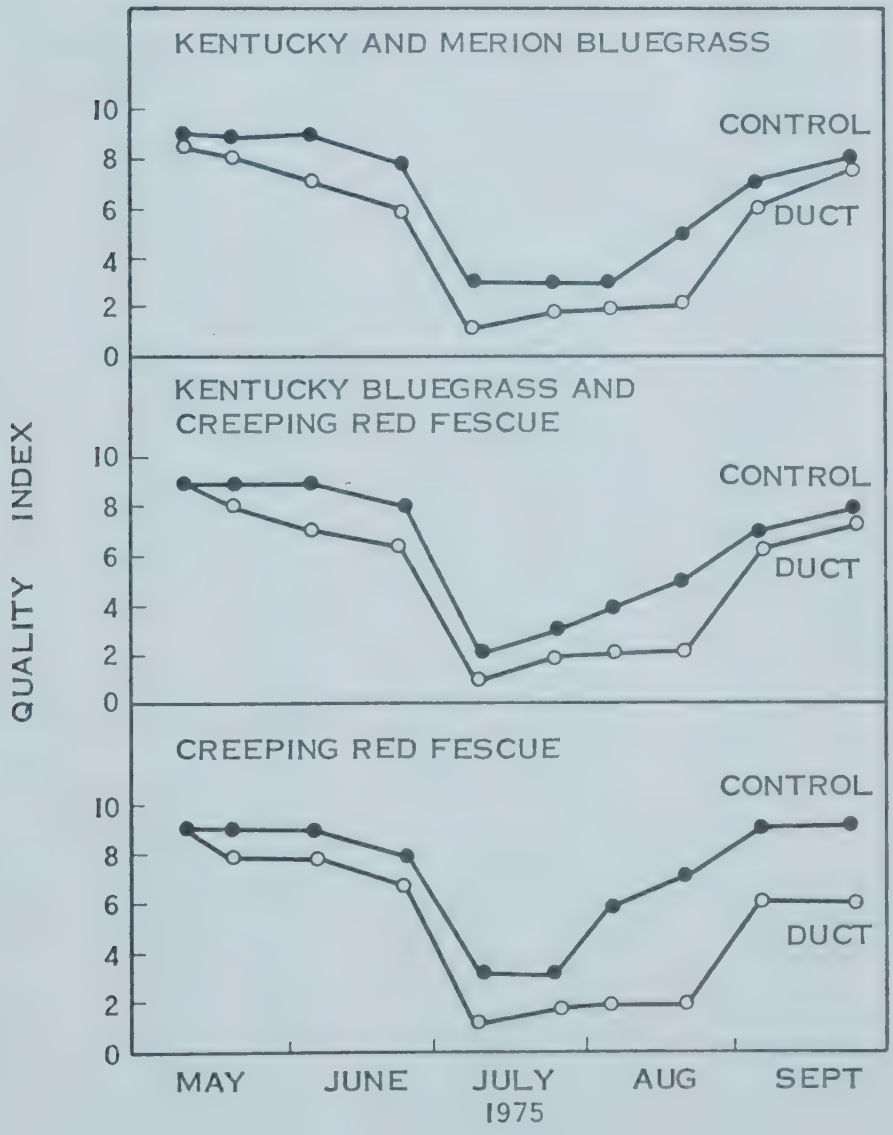
TEMPERATURE PROFILES FOR AIR, ROOT−ZONE SOIL AND TOP SURFACE OF INNER DUCT

FIGURE 2



TEMPERATURE PROFILES FOR HEATED AND CONTROL SOILS

FIGURE 3



QUALITY OF TURF GRASSES

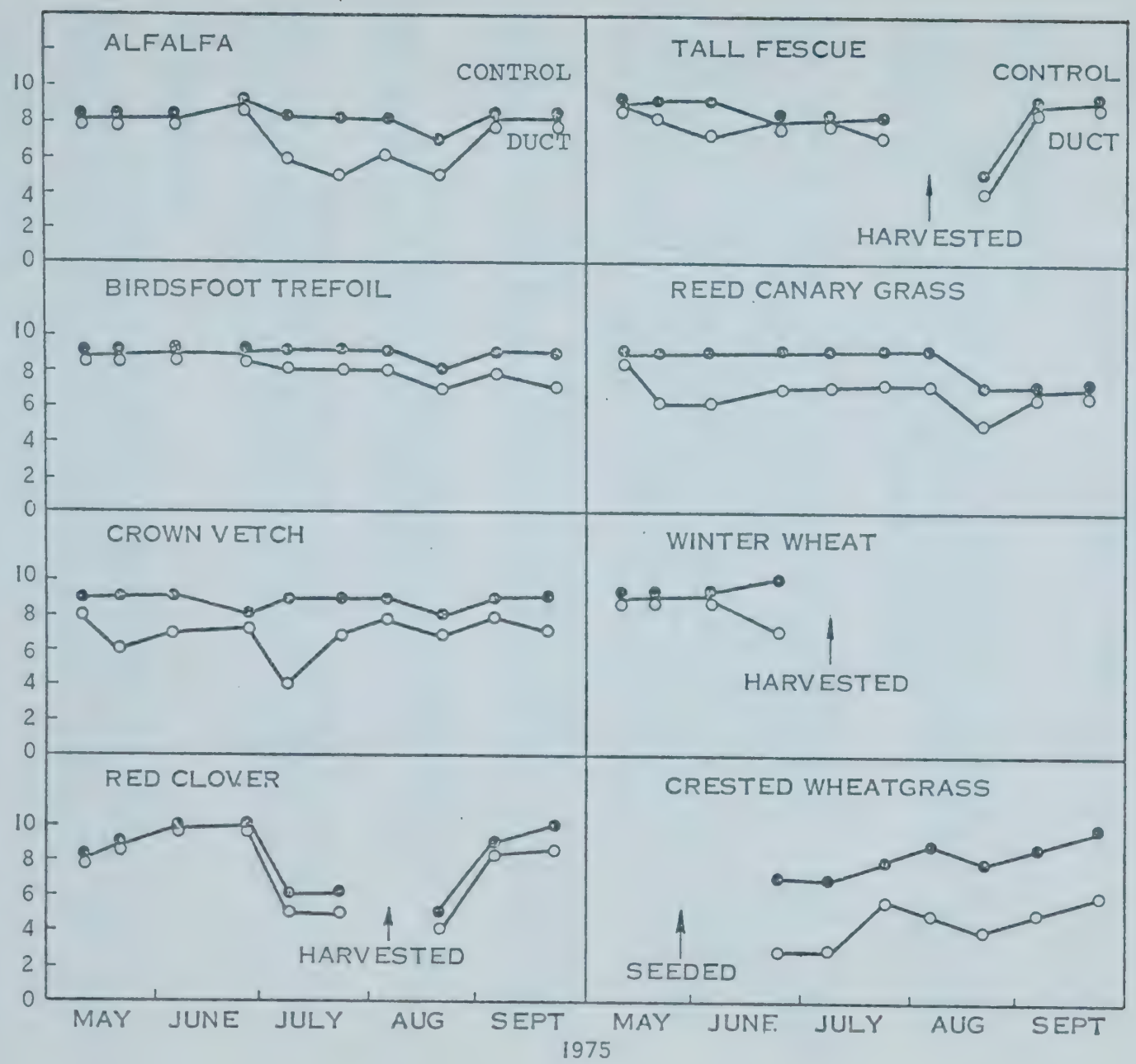


FIGURE 5

QUALITY OF AGRONOMIC CROPS

RECLAMATION RESEARCH AT A MINE SITE IN NORTH COASTAL BRITISH COLUMBIA - A FIVE-YEAR PROGRESS REPORT [1/]

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The Mine and Townsite

Kitsault Molybdenum Mine is an open pit mine situated on the north coast of British Columbia near the Alaska border, about 100 miles northeast of Prince Rupert, at latitude 50°25' N., longitude 129° 25' W. at the head of Alice Arm, a small fiord off Observatory Inlet.

This is a remote wilderness location, more than 600 air miles from Vancouver and the only access is by amphibious aircraft or weekly coastal boat. The pit itself is located five miles from tidewater in rugged, mountainous country at an elevation of 2,500 feet. When the mine was in production, a townsite at tidewater housed approximately 500 people. This isolated community was self-contained and well developed with a four-room school and kindergarten, a resident doctor and nurse, a well-serviced store and a bank. A community centre, complete with four sheets of curling ice, bowling alleys, theatre, library and lounges provided recreational facilities.

The mine was in production from 1967 to 1972 when falling molybdenum prices led to closure. It will be reopened when economic conditions permit. Meanwhile, the sole residents are a caretaker and his family and occasional work crews.

Mining was by standard open-pit methods with a thirty-five foot bench height. Ore-bearing rock was trucked to a primary crusher at the mine site and the rock dump was alongside the pit.

On completion of mining the pit was projected as being 500 feet deep with an area of 280 acres, the projected waste dump of 80 million tons of coarsely broken rock was to cover 600 acres; additional is the area occupied by the mine plant.

The Environment

The terrain is the usual rugged topography of coastal British Columbia with mountain peaks to over 4,000 feet elevation. Two creeks drain the mine area, flowing through almost vertical canyons. A five-mile road from

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1/ A paper presented at the Annual Meeting of the Ontario Cover Crop Committee held at Guelph, Ontario, December 10-11, 1975.

the townsite provides access to the mine. Previously, access was by helicopter only, or a full day on foot by an experienced man.

The climate is typically coastal with high precipitation, well distributed throughout the year, including 120 inches of snow in the pit area. Usually there is more than 3 inches minimum precipitation each month; winter temperatures occasionally drop to 30° F. Growing seasons are short and extremely variable. In two of the five years that the mine has been under observation there has been intermittent snow fall at the mine site as late as July. Along the Inlet, snow has lain in sheltered places down to 500 feet at the beginning of August. The typical Kitsault day is misty, wet or snowy, but on clear days the scene is one of unsurpassed beauty.

Because of inaccessibility there has been no logging in the area except in the immediate foreshore and tidewater area. Tree cover is principally hemlock and amabilis fir. These stands are degenerate. Trees are grossly over-mature with many dead snags. The bulk of the timber is unsound.

There is very little wildlife in the immediate mine area because of the unfavourable terrain. Large mammals are few, with the notable exception of black bear. The occasional wolf has been seen. There are seasonal waterfowl on the tidal flats and a salmon run that brings commercial fish boats into the Arm. Seals and killer whales follow the salmon.

Reclamation Requirements

It is insufficient for reclamation concern to be directed only to the pit area - it must encompass the whole site.

There are four areas of environmental concern:

1 - the development of Kitsault townsite and its treatment after abandonment;

2 - the disposal of tailings;

3 - the treatment of the minesite and roads;

4 - the treatment of the waste dumps.

Initial proposals were based on dependence on natural processes. This was justified on the basis of the remote and inaccessible nature of the mine. These proposals were not acceptable to government and a revegetation program was required under the provincial reclamation regulations. However, the period of disuse has allowed valuable observations to be made regarding natural revegetation possibilities and it is clear that considerable areas of disturbance will revegetate naturally.

A two-phase reclamation strategy has been adopted. One phase is to determine the extent to which natural revegetation can be reasonably expected to succeed in the northwest coast environment, the other is directed toward increasing knowledge of artificial reclamation.

Early denudation along Observatory Inlet

Twenty miles from Kitsault there is the site of a once flourishing community, Anyox. To a previous generation Anyox was a town of 2,700 people with a thriving community life, an underground mine and the largest copper smelter in the British Empire.

All that survives are a few charred remnants where dwellings once stood, a drinking fountain in the midst of the bush, fire hydrants, a number of concrete shells that once housed the concentrator and smelter, two large chimneys, a cemetery and a hole in the side of the mountain.

Anyox contributed materially to the economic prosperity of British Columbia. During the operation of the smelter from 1914 to 1935, 140,000 ounces of gold, 8 million ounces of silver and 700 million pounds of copper were produced. But the operation left its mark along many miles of the upper reaches of Observatory Inlet. Gross atmospheric pollution resulted in extensive areas of fume-killed timber all along the Inlet during the 1920s and 1930s. Effects were felt for a distance of sixty miles while trees were reported killed for twenty-five miles. One hundred and twenty-seven million board feet of timber was killed; additional were immature timber and trees below the merchantable sizes of that time.

Subsequently, at least four fires through the fume-killed timber completed the destruction along Observatory Inlet and destroyed Anyox itself.

Thus the process of natural revegetation has been subjected to a most severe test. Probably no area on the Pacific Coast has been subjected to such harsh treatment.

The area immediately adjacent to the smelter was by far the most severely damaged. Recovery here has been slow but is progressing. The townside has been occupied by willows, alder and hemlock, but the smelter waste and other toxic deposits remain bare. Further from Anyox, but still in the fume-affected region, a new forest has developed under the snags of the killed timber.

To provide information of reclamation potential at Kitsault, an ecological study has been made of the Anyox denudation and recovery. This has been reported in detail in a Ph.D. dissertation by Errington (1975).

The Town Site

Regrettably,when Kitsault townsite was established, all vegetation was stripped from the site. The stark appearance of the bare slopes contrasted with the grandeur of the surrounding scene of fiord, ice fields and tree-covered mountain sides.

Considerable effort has been expended in making good this ill-considered clearance. Residents developed their house surrounds. Under the impetus of the reclamation program, plans for landscaping were prepared and a gardener employed. Soil was hauled in to cover exposed gravel ridges, advice was sought as to suitable trees and shrubs for ornamental planting and raw banks fertilised, seeded to grass and/or planted to trees. Ornamental flower beds were planted. Although there is little horticultural knowledge or experience relating to north coast conditions, by the time the mine closed the raw appearance was much ameliorated. In a very few years Kitsault would have been a well-established, attractive township with a stable community that would have done much to reduce the problems of high labour turnover that is a major difficulty in such northern mines.

With the closure of the mine, the people moved out. Seeded slopes and natural regrowth of alder and willows have benefitted from the absence of human pressure. A considerable amount of tree planting, particularly of lodgepole pine, was done during the last months before closure and these trees are now well established with good colour and growth and strong leading shoots. Re-invasion of, particularly alder, but also willow and western hemlock, has been significant. Thickets of alder eight to ten feet tall have developed on bare areas within the townsite and individual saplings are growing in houseyards and along roadsides. Growth is rapid. In the absence of human intervention it seems clear that the townsite will rapidly revert to its prior forested condition. When the mine is re-opened, considerate handling will allow the rapid development of an attractive community.

The Kitsault case indicates that the barrenness characteristic of many such wilderness mines need not be.

On final closure, minimal treatment to speed up natural processes only will be necessary to reclaim the townsite.

Tailings Disposal

During the operation of the mine, spent crushed rock, or tailings, were discharged into a creek at the minesite and thence into Alice Arm. The creek ran white and the discharge coloured the inlet for a distance of several miles. Shoreline marine life disappeared and the mud flats at the head of the Arm were barren. There were indications of adverse effects on the salmon run.

With the closure of the mine,discharge of tailings ceased. Recovery has been rapid. The creekbed was flushed clean by the first spring run-off. Tidal action has rehabilitated the shore line and mud flats. Within one season, large numbers of small barnacles and sea wrack colonized the previously bare rocks at the entrance to the creek. The tidal flats are green with marine weed and tidal marine life is plentiful.

It is unlikely that the previous surface discharge will be permitted when the mine is brought back into production.

The Mine Site

The mine itself cannot be seen from the shore of the inlet or, indeed, from any vantage point other than the surrounding inaccessible mountain peaks.

Because of the nature of the mine, which must progressively increase in circumference as it increases in depth, progressive reclamation is impossible. The pit in its final configuration will comprise a series of rock terraces, extending to the pit bottom, with a core of untouched rock forming an island in the centre of the pit. The final appearance may be likened to a huge amphitheatre with a central hub and terraces ascending the mountain on the upper side.

On completion of mining, proposals are to divert a small watercourse to flood the workings, thus forming a lake. The walls that will remain above the surface of the water cannot be revegetated artificially. They will consist of natural rock surfaces and, especially in the case of the walls, are unlikely to provide a suitable media for planting or seeding. Under the extremely humid conditions some natural growth may establish itself in the rock fissures. On the terraces, ripping should allow a suitable medium for plant growth. An alternative will be to blow the walls to destroy the mine configuration and bring detritus down onto the terraces.

The access road is unlikely to long remain open once maintenance ceases. Indications are that there will be invasion of hemlock and alder. These are prolific on roadsides and fill slopes, particularly on the lower portion of the road.

The Waste Dumps

Natural Revegetation

It is hoped that under the humid coastal conditions natural processes may provide for revegetation over considerable portions of the dumps. Colonization of natural rock slides also provides evidence in support. The question may well be determined by the length of time that we are prepared to wait upon natural processes in such remote situations and the extent to which the slopes

are left at the biological rather than the physical angle of repose. Long-term ecological studies are intended to clarify the probable course of succession and provide some indication of the time sequence.

In 1970, while the mine was still in production, a level area of freshly tipped waste rock 100 x 200 feet was reserved for long-term study. Observations are made at intervals. After five years progress has been slight. One plant of rye grass, Lolium perenne, appeared in 1972 and remains today. Subsequently, one patch of moss originating from bear faeces has extended to about eighteen inches. During summer, 1975, a single stem of fireweed, Epilobium, and a small group of Rubus spp. seedlings forming a 9-inch diameter circle, also originating from bear faeces, were noted.

In other parts of the mine site naturally seeded plants are appearing. These plants are still few in number, but the significance of slope is becoming apparent. Speculating, it may be that revegetation of slopes may be more easily obtained through slope modification alone than through attempts at artificial establishment of vegetation on steep unmodified banks.

Despite the absence of plants, interesting observations can be made on the rate of weathering and breakdown of the waste rock. A clear relationship is apparent between the physical condition of the rooting medium and revegetation -- the finer the "soil" the more likelihood of natural invasion. It has also been found that the superficial surface layer, apparently unchanged other than the breakdown of pieces of shale, often comprises a thin surface pavement little thicker than one layer of rock fragments with disintegrating material below.

1970 Seeding Trials

These trials comprise 400 sub-plots on a level 200 x 100-foot area of spoil. Seed, fertiliser and muskeg peat applications were made in late July, 1970. There are four site treatments that each received seven seed mixtures comprising 25 different grass and legume varieties.

Treatments

Treatment A - Broken unweathered rock, as dumped from the pit, levelled.

Treatment B - Broken unweathered rock, as dumped from the pit, levelled. 13-6-10 (N.P.K.) commercial fertilizer at 500 lbs./acre.

Treatment C - Broken unweathered rock, as dumped from the pit, levelled. Muskeg peat spread uniformly at 6 cubic feet/40 square feet.

Treatment D - Broken unweathered rock, as dumped from the pit, levelled. Muskeg peat spread uniformly at 6 cubic feet/40 square feet. 13-6-10 (N.P.K.) commercial fertilizer at 500 lbs./acre.

Seed Mixtures

Mixture #1:
30% Perennial rye grass
20% Creeping red fescue
20% Chewing's fescue
20% Poa trivialis
5% Red top
5% White Dutch clover - - - - - - - Sowing rate 71 lbs/1000 sq.ft.

Mixture #2:
20% Annual rye grass
25% Creeping red fescue
20% Chewing's fescue
15% Kentucky bluegrass
15% Canada bluegrass
5% Highland bent - - - - - - - Sowing rate 71 lbs/1000 sq.ft.

Mixture #3:
20% Double cut red clover
18% Alsike clover
15% New Zealand perennial rye grass
10% Climax timothy
5% H 1 rye grass
10% Tall fescue
5% Red top
12% U.S. perennial rye grass
5% New Zealand wild white clover- - Sowing rate 100 lbs/acre

Mixture #4: Reed canary grass

Mixture #5: Legume mixture - 50% Sainfoin
50% Birdsfoot trefoil

Mixture #6:
30% Timothy
20% Perennial rye grass
30% Meadow fescue
10% Red top
10% Alsike clover

Mixture #7:
33.3% Spring rye
33.3% Barley
33.3% Winter vetch

All legumes were double inoculated. Observations have been made at

intervals since establishment. There have been no subsequent fertilizer applications or other treatment.

Distinct differences are apparent between seeds mixtures in speed of establishment, survival and total leaf production.

It has been shown that commercial grass mixtures can be grown on unweathered fragmented rock, with the addition of fertilizer or organic material. Fertilizer and peat applications, when applied separately, result in a significantly better plant cover, but in combination are poorly productive. Organic material or "soil" is not an essential concomitant for successful seeding. The annuals, rye, barley and winter vetch perform well in the first year but are not self-seeding. Mixtures containing legumes perform significantly better than do grasses alone. With heavy-leafed grasses and legumes, an appreciable accumulation of organic material can occur after the first year with a full stand of grass and an organic mat over large rocks and complete cover of bare surfaces after the second season. A most significant observation is the contribution that the clovers, particularly birdsfoot trefoil, after a slow start, have made to the grass stands.

1974 Observations

Treatment A - Broken rock, no additives. Vegetative cover minimal, visually estimated between 1-5% cover. Creeping red fescue and red top have established and persisted, but sparsely.

Treatment B - Broken rock, plus fertilizer. Mixtures #3 and #5 excellent and Mixture #1 good, with full sward and build-up of organic layer. The main species are creeping red fescue, red top, timothy, orchard grass, blue grass, alsike clover, red clover, white clover, birdsfoot trefoil and a lesser proportion of sainfoin. In Mixture #3 there is an estimated 60% grass and 40% clover cover.

Treatment C - Broken rock, plus peat. Mixtures #1 and #5 excellent and Mixture #6 good, with full sward and organic build-up. Mixture #6 has been invaded by other species and is strong to timothy, creeping red fescue and red top. Mixture #1 is excellent as to grasses, with creeping red fescue, red top and white clover predominant, but the clover is in very small percentage. Mixture #5 is very vigorous and strong, particularly birdsfoot trefoil. Sainfoin observed.

Treatment D - Broken rock, plus peat and fertilizer. Very [illegible]owth and generally poor. It would appear that some interaction between the peat and the fertilizer has resulted in the immobilization of the fertilizer.

Some invasion of alsike clover, white clover, birdsfoot trefoil, timothy, orchard grass and Canada blue grass has occurred in small areas one foot in diameter where trees have been planted and failed. The invading grasses have found favourable seed beds in the rocky "tilth" resulting from filling of planting holes with finer rock fragments.

Other species noted but not mentioned above because they were not dominantly strong are reed canary grass and perennial rye grass. A single plant of alfalfa was found and it looked extremely healthy and vigorous. This plant probably originated as a crop contaminant in the seed mixture, but is certainly a species worthy of record.

Observations made in August, 1975 show the relative success of individual treatment applications to be unchanged. However, the impression was obtained of an over-all reduction in vigour. It is understood that growth was slow in starting because of the late season. Certainly the grasses were poorly advanced compared to previous visits, with flowering not started in most instances. It may be that this adverse impression is merely the result of the vagaries of the northern climate, which present problems in making comparative annual assessments.

The seeded plots show significant development of moss between the rock fragments. This moss appears to be associated with the build-up of organic material. Naturally seeded hemlock germinants are now appearing in the moss. Speculating, it might well be that the long-term benefits of the treatments will result less from the establishment of a grass sward that may or may not be permanent, but from the provision of conditions that allow reversion to an early natural successional stage of vegetation establishment.

1975 Seeding Trials

The initial trials were on level ground. In August, 1975 two series of grass/legume trials were set out on waste rock slopes within the dump area.

The slopes were of coarse rock fragments, as dumped, and at the natural angle of repose.

The following seed mixtures were applied:

Mixture A -	Grass species	- red top creeping red fescue timothy Canada blue grass, orchard grass, tetraploid perennial rye grass.	In equal proportion by weight. Rate of application, 50 lbs./acre.

Mixture B - Legume species -	alfalfa birdsfoot trefoil sainfoin white clover alsike clover	In equal proportion by weight. Rate of application 75 lbs./acre.
Mixture C - Legume/grass mixture: (1)			
	10% red top 15% timothy 15% Canada blue grass 20% birdsfoot trefoil (inoculated) 25% sainfoin (inoculated) 15% alsike (inoculated)	Rate of application 75 lbs/acre.
Mixture D - Legume/grass mixture: (2)	15% tetraploid perennial rye, 15% orchard grass 10% alfalfa (inoculated) 20% white clover (inoculated) 20% cicer milk vetch (inoculated)	Rate of application 75 lbs/acre.

Ten plots,each 20 feet wide and running from top to bottom of the dump slopes,were laid out on southeast and northwest aspects. The southeast slope was 100 feet and the northwest 200 feet long. There was no modification of the surface. N.P.K. fertiliser was applied at a rate of 333 lbs./acre.

Slope stability

On both sites slopes are extremely unstable. The sheering effect of even slight surface movement can have a major influence on revegetation prospects. To obtain some indication whether there is surface movement, three paint bands, each fifteen feet long, were painted across the slopes alongside the seeded plots. Some indication of movement will be provided by any discontinuity in these bands.

Tree Planting

In October, 1970, Sitka spruce, western hemlock, amabilis fir and lodgepole pine were planted in the two-feet separation strips between the grass/legume plots. The trees were bare rooted 2 + 1 transplants. A pick was used to prepare planting holes, no soil was introduced and the trees were planted directly into the waste rock. Holes were filled with relatively smaller rock fragments from the immediate surface. A handful (approx. 2 oz.) of commercial 13-16-10 N.P.K. fertilizer was spread around each tree. Half of the trees died during the first year, probably consequent on poor supervision of unskilled planters and a subsequent dry summer.

An assessment in July 1974 showed that all species had survived

when planted carefully, but that lodgepole pine was by far the most vigorous, with good colour, growth and strong leading shoots; under all conditions it had performed best of the species tried. Hemlock was established; amabilis fir was, in the main, healthy, but had shown little growth; Sitka spruce was of very variable condition. But with the exception of lodgepole pine all species tended to be chlorotic and without vigour.

A strong interaction with the legumes was observed. All species showed enhanced vigour and good colour wherever trees were in proximity to seeded plots with strong clover components.

In contrast to the 1975 grass/legume assessment, a favorable change was noted in the performance of the tree species. As noted previously, only lodgepole pine had been vigorous and in good health. The other species were merely surviving with little or no growth and poor colour. In August of this year almost all the trees looked healthy, were of good colour and showed significant leader growth. It may be that after five years their root development is sufficient to bring them out of check. To date it can only be said that lodgepole pine has proved itself during the five-year period, is well established and growing vigorously, and that the desirability of growing it in association with nitrogen-fixing species has been established.

Conclusions

Reclamation and field scale rehabilitation at Kitsault is in the initial stages only, but useful insights have been obtained.

With the mine closure, the absence of operating personnel has limited the scale of the enquiry already begun, but the absence of human pressures has permitted the natural colonization of much bare ground.

Under the extreme conditions of the waste dumps the practicality of establishing a plant cover on level waste rock deposits has been demonstrated. It remains to be shown that equal success can be obtained on the steep slopes of these dumps.

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PROPERTIES OF SLOW-RELEASE FERTILIZERS

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Establishment and growth of vegetation on the materials found at reclamation sites generally requires the addition of some soil amendment or fertilizer to improve the status of the material as a medium for plant growth. The amendments in use are limestone and gypsum. While they may supply the plant nutrients calcium and sulphur they are principally used to correct an acid pH or excessive salinity problem. Fertilizers, on the other hand, are used because they contain one or more of the major plant nutrients, nitrogen, phosphorus and potassium and, in specific situations, sulphur and micro-nutrients. The amount and analysis to be used is dependent on the specific requirement for each nutrient element at each site. It deserves repeating that the amount and analysis is dependent on the specific requirements of a site, hence a general recommendation is about as meaningful as making a statement that a baby needs food without knowledge of the baby's age.

Over the past two decades considerable research has been directed toward development of slow-release materials. The objective of the development of a slow-release fertilizer was to obtain a material that would release to solution only a small quantity of the plant nutrient at a time, hopefully the rate of release would be equal to the rate of uptake by the growing plant. The objective can be achieved by (1) using chemical compounds having properties of slow breakdown or dissolution per se, or (2) by physically coating fertilizer pellets with semipermeable membranes or inert materials.

As was previously mentioned, fertilizers generally consist of three plant nutrients; nitrogen, phosphorus and potassium. They are manufactured by blending together the appropriate carriers of the three nutrients and as such are known as complete fertilizers. There are, however, no slow-release forms of potash on the market today; the potassium salts used in formulating fertilizers, KCl and K_2SO_4, are completely water soluble. The principal slow-release form of phosphorus is bone-meal, a by-product of the meat packing industry. Its use, however, is limited to the specialized ornamental horticulture trade because of price. One might also argue that rock phosphate is a slow-release form of phosphorus but to realize benefit from finely ground rock phosphate the pH of the medium should

be 5.0 or less. All other carriers of phosphorus are not considered slow-release materials. Since rock phosphate and bone meal are not used as phosphate carriers in commercial fertilizers, it is obvious that it is only the nitrogen component of a fertilizer can be considered as a slow-release material. Therefore, by definition, a complete slow-release fertilizer does not exist but, rather, fertilizers in which part or all of the nitrogen carrier only is in a slow-release form.

There are always exceptions, and to keep the record straight reference must be made to semi-permeable membrane coatings applied to complete fertilizer pellets. One material of this type was developed in the U.S.A. and retailed under the trade name of "Osmocote".* The high cost per pound of plant nutrient limited its use and, furthermore, availability at this time is questionable.

The remainder of the paper will be concerned with slow-release nitrogen carriers; materials which may form part or all of the nitrogen component of a complete fertilizer.

The slow-release property of manufactured nitrogen carriers is basically an attempt to mimic the microbiological breakdown of the natural organic matter in the soil. The rate of release of nitrogen from soil organic matter is dependent on the activity of soil microflora an activity largely controlled by temperature and moisture. Plant growth is also largely controlled by the same two environmental factors so that as the activity of the soil microflora rises and falls, due to changes in temperature and moisture, the potential for plant growth likewise rises and falls. Theoretically, the release of N from the slow-release carrier may be considered to be 'in phase' with plant growth.

The first manufactured slow-release nitrogen carrier to receive widespread use, and which still dominates the market, is urea-formaldehyde (Table 1). The material is produced by reacting urea with formaldehyde, the solubility of the product depending on the ratio of urea to formaldehyde. The more complex the molecule, the slower the rate of decomposition, since nitrogen release is dependent on the microbiological decomposition of the molecule. Where the ratio is less than 1.0 there is strong resistance to decomposition, with preferred ratios in the range of 1.5 to 3.0. The material should have a total nitrogen content of not less than 35% and also have

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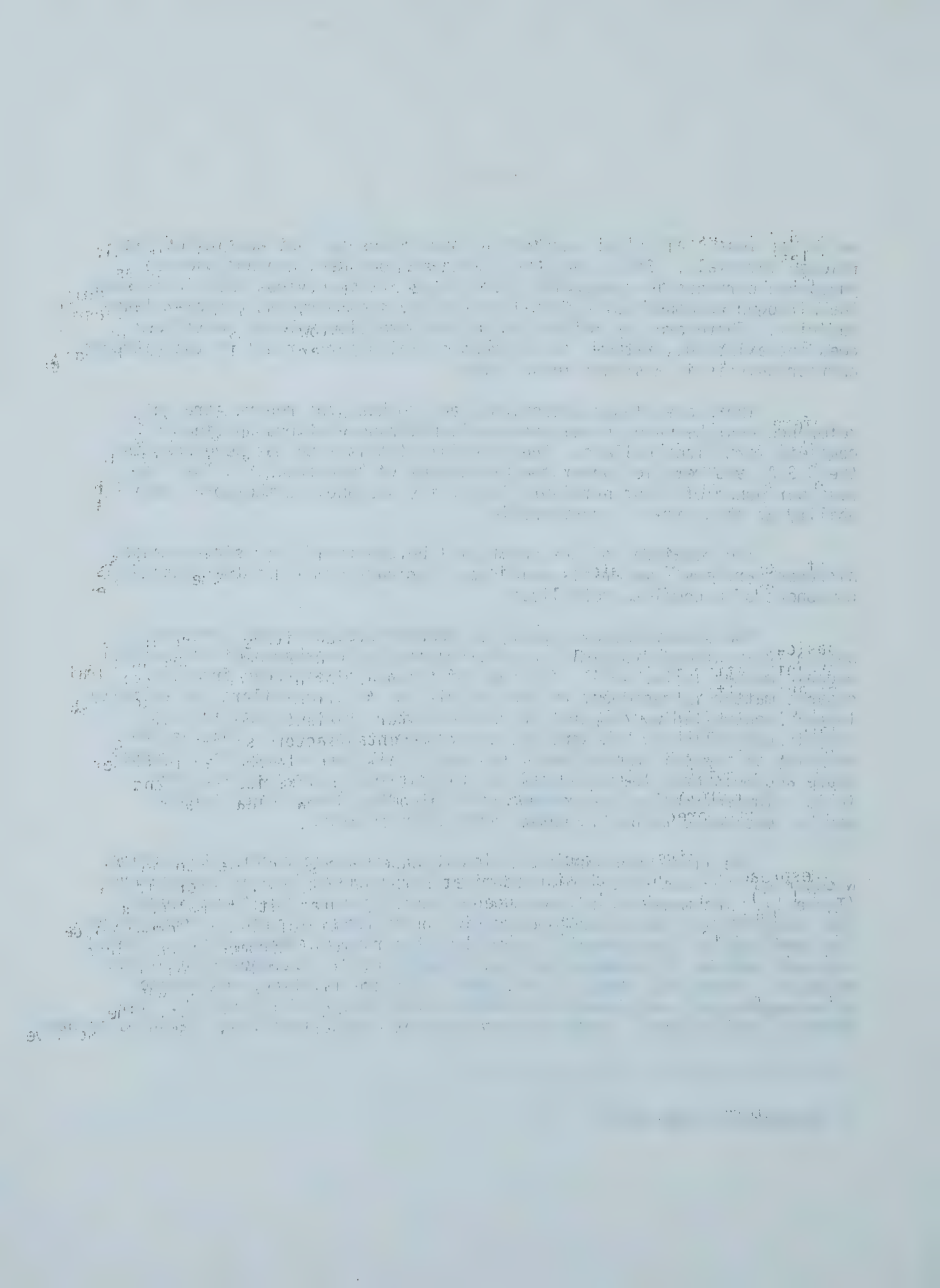
* Registered Trade Mark



an Activity Index of not less than 40 where the Activity Index is defined as:

$$AI = \frac{\%\ CWIN - \%\ HWIN}{\%\ CWIN} \times 100$$

where CWIN is the percentage of the total nitrogen insoluble in cold water (25°C) and HWIN is the percentage of total nitrogen insoluble in hot water (98°C). Nitrogen release is not influenced by granule size, is slightly greater at acid pH levels and is of limited value at soil temperatures of less than 15°C. In a recent study on turf at Guelph, a single application of urea-formaldehyde produced excessive growth in May, but was inferior by the end of the growing season, (Fig.1).

Table 1: Some Properties of Nitrogen Carriers

Carrier	Chemical Form	Nitrogen Concentration (%)	Solubility in Water (g/100 ml)
Urea-formaldehyde (U.F., Ureaform)*	Organic	38	Trace
Crotonylidene Diurea (C.D.U., Floramid)*	Organic	32	.12
Isobutylidene Diurea (I.B.D.U.)*	Organic	32	.01
Blood Meal	Organic	13	0
Activated Sewage Sludge	Organic plus NH_3	5-6	Trace
Sulphur Coated Urea (S.C.U.)*	Inorganic	32	20**
Metal Ammonium Phosphates	Inorganic	8***	.05
Urea	Inorganic	46	>100
Ammonium Nitrate	Inorganic	34	>100

* Synonymous terms.
** In seven days at 38°C
*** "Mag-Am P" analysis of 8-40-0-14 (Mg).

Two other manufactured, organic, slow-release nitrogen carriers, which are also polymers of urea and aldehydes, are I.B.D.U. and C.D.U. The rate of release of both materials is increased with a decrease in granule size, lowering the pH, and by increasing soil temperature and soil moisture. The reaction involved in release of nitrogen from I.B.D.U. is thought to be a release of urea by hydrolysis of the molecule rather than microbial action. The materials are not commercially available in Canada at this time, although I.B.D.U. is being used in formulation of lawn fertilizers in the U.S.

By-products of sewage treatment and the meat packing industry may also serve as slow-release N carriers. The two main carriers are bone meal and "Milorgonite".* Both materials, while being satisfactory slow-release materials, are restricted to specialized turf or horticultural use because of price. Liquid sewage sludge from secondary treatment plants, however, may have some value where it can be utilized locally, thus keeping transportation costs at a minimum. The metal content of the sludge should be given consideration if the area of application is ever to be returned to a food production system.

During the mid-sixties the Tennessee Valley Authority developed sulphur-coated urea where the nitrogen release is controlled by microbial breakdown of a wax used in sealing the tiny holes or cracks formed in the molten sulphur coating as it cools. The rate of release is controlled by the thickness of coating, type of wax and inclusion of microbicides, soil temperature and soil moisture. The rate of release is less from surface-applied material than from incorporated S.C.U.

Work at Guelph on turf has shown S.C.U. to be superior to U.F. and sewage sludge, in terms of reducing the flush of spring growth and in prolonging the growth to the end of the season (Fig.1). Production of Reed canarygrass (Phalaris arundinacea L.) with S.C.U. was maintained into the year after nitrogen applications were discontinued (Table 2). A December application of S.C.U. was superior to a mid-May application and the residual influence continued at a higher level than where urea was used, even where split into three applications per season.

Sulphur-coated urea is now being produced on a commercial scale by Canadian Industries Limited.

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* Registered Trade Mark

Several divalent metals (Mg, Fe) form metal ammonium phosphates which have slow-release properties due to the low water solubility of the inorganic molecule. The rate of nitrogen release, however, appears to be greater than the solubility would indicate and release decreases with increase in granular size. The material would have additional advantages where phosphorus and magnesium are also required as plant nutrients,such as at the establishment stage of grasses and legumes. Cost of the material has also limited its use to the specialized interior horticulture industry.

The choice of a nitrogen carrier for reclamation work eventually must be based on one or more of the following criteria: (1) reduction in number of applications, (2) freedom from fertilizer burn of seedlings, (3) loss of nitrogen through excessive leaching in a porous medium, and (4) the cost per pound of nitrogen. The last criteria will most often be the one which tips the balance.

Table 2: The response of Reed canarygrass to time of application and nitrogen carrier. Nitrogen applications commenced in December 1970 and were discontinued in 1972.

Carrier	Time	Yield		
		1971	1972	1973
		(kg dry wt/ha)		
Urea*	Dec. only	9100	7580	2860
	May only	7470	7440	3320
	1/3 Dec., 1/3 May, 1/3 July	6950	8190	4740
S.C.U.*	Dec. only	5570	7380	5920
	May only	4580	7250	5710
Check		4230	2370	2990

* Nitrogen applied at 240 kg N/ha

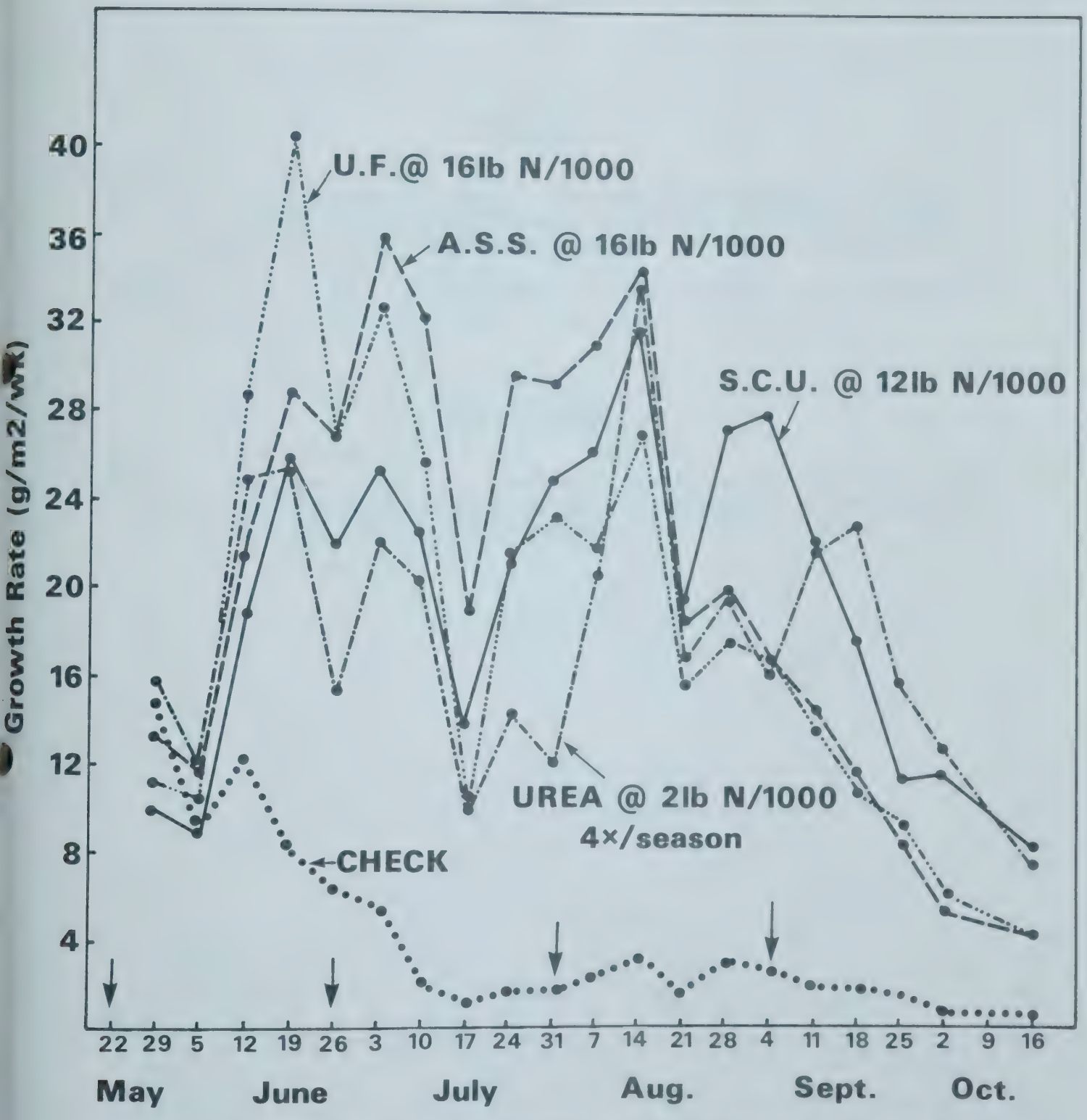

Figure 1. The growth rate of a bluegrass - red fescue turf fertilized with a single application of sulphur-coated urea, urea formaldehyde, activated sewage sludge and four applications of urea.

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Figure 1. The growth rate of a bluegrass - red fescue turf fertilized with a single application of sulphur-coated urea, urea formaldehyde, activated sewage sludge and four applications of urea.

RECLAMATION STUDIES ON INDUSTRIAL BARRENS IN THE SUDBURY REGION

- A PROGRESS REPORT -

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This slide presentation showed progress in revegetation research carried out under the sponsorship of the Ministry of Natural Resources, Sudbury Region, and the Regional Municipality of Sudbury, following the presentation made at the 1974 Cover Crops Committee Workshop. The following is a summary of the main points discussed:

1. Semi-operational grass seeding north of Coniston. Six acres of the almost barren valley of Coniston Creek, 2 miles north of Coniston, sown to Canada Blue Grass in August 1974, has developed a good sward in its first year of growth. This fine sandy soil, having a pH of approximately 4.0 at the surface and total copper and nickel contents of up to 450 ppm and 500 ppm, respectively, was treated with 2 tons per acre dolomitic limestone and sown to Poa compressa at 40 lb/seed acre. Three acres were fertilized with 1/2 ton/acre 7-7-7 and three acres with 1/2 ton/acre 5-20-10. Biomass determinations carried out in the summer of 1975 showed significantly greater yield on the area fertilized with 7-7-7.

A number of colonizing species were in evidence during the first summer. The following table shows the species arranged in descending order of Density/Frequency Index, as determined on the basis of 210 1 m^2 quadrats.

Species	Common name	Density/Frequency Index (%)
Salix spp.	Willows	50.0
Carex scoparia	Sedge	15.3
Agrostis gigantea	Redtop	8.9
Trifolium spp.	Clover (White & Alsike)	7.5
Agrostis scabra	Tickle Grass	3.2
Chenopodium album	Lamb's Quarters	2.5
Juncus bufonius*	Toad Rush	2.2
Melica smithii*	Melic Grass	1.6
Equisetum sp.	Horsetail	1.2

Species	Common name	Density/Frequency Index (%)
Glyceria canadensis**	Rattlesnake Grass	1.2
Chenopodium glaucum	Oak-leaved Goosefoot	0.8
Geranium bicknellii	Cranesbill	0.8
Rumex acetosella	Sorrel	0.8
Typha latifolia**	Cattail	0.8
Anaphalis margaritacea	Pearly Everlasting	0.4
Anthemis cotula*	Stinking Mayweed	0.4
Fragaria virginiana	Wild Strawberry	0.4
Gnaphalium sp.	Cudweed	0.4
Marchantia polymorpha	Liverwort	0.4
Prunus pensylvanica	Pin Cherry	0.4
Rosa sp.	Wild Rose	0.4

Species marked with an asterisk are not normally found in the area, and were probably present as contaminants in the seed supply. Species marked with a double asterisk became established on that part of the area bordering the creek. Willows became established most abundantly in the north-eastern section of the plot, the portion facing the prevailing wind. This phenomenon, not surprising in view of the wind-dispersed seeds of the willow, has been noted in a number of experiments. Another striking feature was the fact that establishment of adventives was best in areas where grass establishment was poor, so that the pioneers did not suffer from competition. This could be an important factor in cases where the initiation of natural succession is considered to be desirable.

2. Strip cultivation. On the Coniston site, cultivation of the fine sandy soil can give rise to the problems of wind erosion, though Canada Bluegrass can cope quite well with low dune formation. However, a small plot was set up in 1974 in which strips of soil were cultivated with a rototiller and strips of equal width left uncultivated between them. Lime, fertilizer and seed were broadcast over the whole 10 m x 10 m plot. Establishment in the cultivated strips was excellent (the grasses in this case being a mixture of Agrostis gigantea and Agrostis scabra) and even in the first season there was some migration of grass into the uncultivated strips, particularly along cracks in the soil formed during wetting/drying cycles.

3. Tickle Grass (Agrostis scabra) as a species for reclamation.

Although this native species is outstanding in its ability to colonize the industrial barrens of the Sudbury area, particularly if minimal amelioration of pH or nutrient status is carried out, small scale trials suggest that it should be used with caution for primary sward establishment. On fertilized ground it gives a very lush growth in the first season, but tends to act more as an

annual than as a perennial. There is, therefore, rather poor growth of the species in the second season due to the heavy thatch formed in the previous year. In this way it differs from Poa compressa, which forms new shoots readily in the second season from rhizomes, Poa compressa also forming a more open stand than Agrostis scabra, allowing the establishment of other species. The most important secondary colonists moving into a Poa compressa or Agrostis scabra sward are Agrostis gigantea and Carex scoparia. It appears that it is not necessary to sow Agrostis scabra in an area so long as there is a seed source nearby, since it has a very efficient tumbleweed-type dispersal mechanism. Despite its shortcomings, Agrostis scabra is a valuable species as a temporary "space filler" which will eventually be replaced by more permanent species such as Agrostis gigantea. The use of Poa compressa on sandy soil is still recommended in view of its ability to tolerate blown sand accumulation. Once an open sward of Poa compressa is established on such a site, colonization by Agrostis gigantea and willows will follow, with Agrostis scabra acting as a temporary "space filler". In sites less prone to blowing sand, Agrostis gigantea may be used as the sown species.

4. Grass establishment on an open scrub-oak site near Skead.

Though most attention has been given to tree establishment on this site, it was felt that an attempt should be made to find a method of vegetating the barren areas between trees, previous experiments having indicated that tree establishment is more difficult in such exposed sites. The Skead soil, coarser textured than that at Coniston but with a similar pH, also differs from that at Coniston in its lower nickel content and its lower nitrogen content. A preliminary trial with several grass species indicated that nitrogen is a much more essential ameliorant at Skead than at Coniston. One of the native grasses tested at Skead was Deschampsia flexuosa (Wavy Hair Grass), a common species of dry, rocky sites in open woods of the Sudbury area. It was noted with interest that this species showed a definite growth response to N and P fertilizer, although it is normally considered to be a species of acid, low-nutrient soils.

5. Revegetation of barren stony slopes. Small scale trials set up in 1974 showed that it was possible to establish vegetation on a number of completely barren gravelly, stony and rocky slopes, provided that lime and fertilizer was applied. On such slopes, the stony surface, "deflated" by erosion, often tends to act as a seed trap and a mulch, and under the stones a considerable depth of soil may be found. Agrostis scabra and A. gigantea seem to be the best species on such slopes.

In August 1975, a group of primary school students were organized to

carry out manual revegetation measures on a barren area opposite their school. Germination was good and, based on the results of the small scale plot set up in 1974, a good stand of Agrostis scabra and A. gigantea should be achieved next summer.

The manual approach to revegetation of stony hillsides, without site preparation, has two potential applications. The first is the use of volunteer groups for the revegetation of small areas. The second is in the use of aerial fertilizing and seeding. However, some modification might be required for aerial work, particularly in lime application, since the large amount of lime normally required would make aerial lime spreading financially prohibitive. The use of coated seed with lime incorporated is, therefore, being explored, and coated seeds of Poa compressa and Agrostis gigantea are on order. It is hoped that the lime coating will ameliorate the immediate micro-environment of the germinating seed sufficiently to allow its establishment and survival, though it is not known whether further growth and establishment of new plants will follow.

6. Revegetation of barren bog areas. A number of barren bogs occur in the Sudbury area. These are areas of black peat in which vegetation is confined to the edges, though the remains of bog shrubs such as Leatherleaf may sometimes be found. Experiments on such a bog have shown that, not only can sown grasses such as Redtop be established if lime and fertilizer, or even lime alone, are applied, but that a limed unseeded plot will develop a complete cover of vegetation within one season, the dominant adventive species being Typha latifolia, Scirpus cyperinus, Salix spp., Populus tremuloides and Juncus brevicaudatus.

7. pH dynamics in limed and unlimed soils. An intensive pH study has been carried out in the Coniston experimental plot area, aimed at determining how effective liming is in ameliorating pH and how long-lasting the results of such amelioration are. However, even before comparisons between limed and unlimed plots were made, it became clear that there has been a distinct pH shift in the Coniston plot area since work was begun there in 1969. Unlimed soil, which in 1969 had a pH in the range of 3.0 - 3.5, now lies between pH 4.0 and 4.5. This probably reflects the fact that the low pH encountered in 1969 was due to free sulphurous and/or sulphuric acids in the soil resulting from intense fumigation from Coniston and Falconbridge, whereas the closing of the Coniston smelter and the Falconbridge pyrrhotite smelter in 1972 has brought about a considerable reduction in fumigation in the Coniston plot area, so that free acids are presumably leached out.

The comparison between pH of limed and unlimed plots indicates that plots limed at a rate of 2 tons per acre maintain a pH differential of up to 1.0 unit even after four years.

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RECLAMATION RESEARCH METHODS ON COAL MINE WASTES

WITH PARTICULAR REFERENCE TO SPECIES EVALUATION AND ASSESSMENT

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University of British Columbia

Summary and Conclusions

The question of what species to plant on devastated lands is of critical importance to the success or failure of a reclamation program. This paper outlines some methods that may enable the reclamation officer to make that decision with greater confidence.

The forage production data of thirteen revegetation species on nine disturbed areas treated by Kaiser Resources' Environmental Services Department were presented. These were compared with forage production data of various natural communities floristically similar to those adjacent to the disturbed areas. Since these lands are classified as big game winter range, forage production seems a reasonable criterion for assessing reclamation success. Methods for estimating forage production were discussed.

This is an interim report, therefore many of the study's objectives remain unattained: can species' performance be predicted by measuring the site factors prior to planting? If so, can a valid prediction model be formed for each species? In addition to these questions many more demand study. To what extent are our nutrient inputs being recycled by the plant community? If significant internal cycling is taking place then further fertilization is unnecessary. On the other hand, we do not know whether the agronomic species currently in use can survive without intensive resource inputs. It may be more economical in the long run to plant native species at the start of the revegetation program. If our reclamation programs are to become more efficient, these questions should be answered.

In conclusion, future reclamation efforts, particularly in high-altitude areas of British Columbia, will depend on the availability of species capable of colonizing the harshest of sites with a minimum of maintenance. Native, as well as introduced species should be tested under rigorous conditions and certified on the basis of their durability.

Introduction and Review of Literature

When confronted with a new piece of devastated land the reclamation officer must assess the site conditions and prepare a list of the species for planting. Brink (1974) suggests the following considerations in basing the initial stages of revegetation on herbaceous or woody species:

1) rapidity and ease of establishment to provide rooting and canopy to reduce erosion of soil,

2) economy,

3) availability of plant materials,

4) fire control (exclusion of annual weeds),

5) possibility of secondary harvest for domestic and/or native ungulates, and

6) to provide pioneer cover for the establishment of shrubs and trees.

If the decision is for herbaceous vegetation, then which species should be used?

Greater knowledge of revegetation species' tolerances to environmental stresses will help us make more efficient species lists in the future. Two pathways of research may lead us to this end:

1) evaluation of previously treated revegetation areas, and

2) establishment of species trial plots.

Each procedure has its advantages and disadvantages. This paper will discuss both procedures and examine the current work being done in evaluating species performance on Kaiser's properties in the East Kootenays. In evaluating previously treated revegetation areas it is possible to examine the long-term responses of the species to a wide range of physical variables.

In areas where mine reclamation has been practiced and observed for long periods of time it has been possible to qualitatively assess the fitness of many species to the likely range of critical environmental factors. Miles, et.al. (1973) and Medvick (1973) have done so for Pennsylvania and Indiana, respectively, with observations spanning several decades. Unfortunately, in general, Canada lacks a long history of reclamation efforts. Therefore, in attempting to assess the factors responsible for species performance on coal reclamation sites in the East Kootenays of British Columbia, it is necessary to quantify performance, i.e., in terms of aerial production as well as the physical variables; slope, elevation, aspect, soil chemical status, etc.

Quantification of the environmental parameters and their correlation to species vigor is a complex procedure. In addition, the history of such areas is often poorly understood and uncontrolled factors such as wild ungulate grazing, fires and non-normality of factor distribution may contribute to error. Establishment of species trial plots permits us to examine independently the responses of many species to a variety of treatments such as fertilizer and mulch. Although the degree of control over variables is greater, the range of variation is often limited, i.e., it would be very difficult to reproduce the effects of four 300-meter elevation levels within a one-hectare trial plot. Obviously, four trial plots and a four-fold resource expenditure would be required. Also, firm conclusions regarding the fitness of species could only be obtained after many years to ensure that the species will either endure or enable native species to become established.

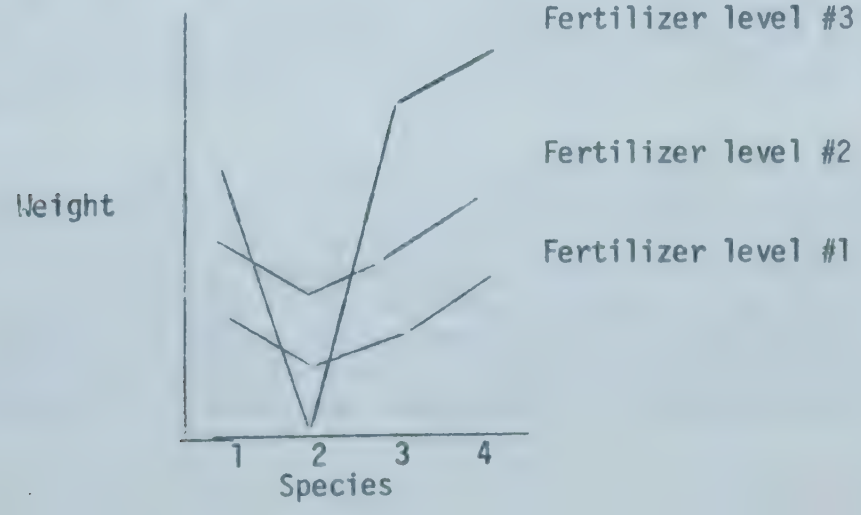
The trial plot method is widely used in mine reclamation (Farmer, et.al., 1974) and most agronomic research. By isolating effects this method enables the researcher to study them, independently and as interactions with other effects. For example, if we wish to study four species and three fertilizer levels, we can set up the following trial plot design:

	Species			
Fertilizer levels	1	2	3	4
1	11	12	13	14
2	21	22	23	24
3	31	32	33	34

Randomization might yield the following treatment combinations:

12	22	21	34
31	33	14	24
32	23	13	11

This pattern is then repeated in perhaps four replications, and might produce the following results:



It would then be obvious that species #2 cannot tolerate fertilizer level #3. Results are then subjected to analysis of variance (Ostle, 1963) to test for significance.

It seems that the evaluation of previously treated areas will yield quick, widely applicable but general information, while the trial plot method will provide long-term, narrowly applicable but rigorous results.

Methods

Evaluation of previously treated areas on Kaiser property in the East Kootenays, British Columbia

Reclamation research in British Columbia, with conditions unique among Canadian provinces, is in the early stages of development. Two important biological questions remain unanswered. What is the ecological amplitude of each of the revegetation species? And, what is the best method of sampling the vegetation?

The purpose of this study is to identify and perhaps define the physical factors influencing growth of thirteen revegetation species on former coal mine sites. If the proposed procedure proves successful, it could provide a technique for species selection in future revegetation efforts.

Nine revegetation sites on Kaiser Resources' properties near Sparwood, B.C. were chosen for this study. Each site had been seeded two and three years ago with a very broad seed mix. On each site aerial biomass data was collected in August, 1975 by sampling at 46 m. intervals on a two-dimensional grid on each area. At each of the resulting 189 sampling stations a labelled stake was driven, and at five points or, in very heavy vegetation, two points about this stake a $1m.^2$ frame was dropped and the enclosed aerial growth clipped by species. The labelled sample bags were then air dried and weighed. At the central point of each station the soil colour, per cent rockiness, elevation, slope and aspect were recorded and a 12 cm. deep soil sample taken. The soil sample was analyzed for pH, organic matter, cation exchange capacity, NO^-_3, K, Ca, Mg, S and particle size distribution.

These physical parameters will serve as the independent variables in a regression analysis (Ostle, 1963) while species dry weights will be the dependent variables. If valid correlations are found between the subsequent statistical models and the species' standing crop, then not only could species vigor be predicted on a given site but its ecological amplitude would be suggested.

The limitations of regression analysis must be remembered. Resultant correlations do not necessarily imply cause and effect relationships. Also, the information gained from the analysis is of a descriptive nature. Thus, whatever correlations do appear should be tested under controlled conditions to learn the specific nature of the species response, if any, to the limiting factors suggested by the regression analysis. If correlations are obtained, the regression equation could be used as a guide to preparation of a seed mix for specific revegetation areas upon measurement of the suggested limiting factors.

Results and Discussion

Unfortunately the soil nutrient analyses haven't been completed at the time of this writing so, of course, there are no regression models to present. However, the aerial biomass data is complete (Table 1). Although all thirteen species were sown on all of the disturbed sites there is a strong segregation of species with sites. The regression analyses will, hopefully, explain the parameters along which this segregation occurred.

More germane to this discussion is evaluation of the revegetation efforts and species performance on a qualitative basis. Have these lands indeed been reclaimed? The Canada Land Inventory lists the disturbed areas studied as prime big bame winter range. From this perspective we might consider the reclamation efforts in terms of their depletion or enhancement of the winter ranges' forage production.

Since we presently have no forage production figures for the undisturbed lands adjacent to the reclaimed areas, we must rely on studies conducted on floristically similar areas. These are summarized in Table 2. Comparison with reclaimed areas suggests which areas are "reclaimed" and those which need further work. Since the initial seeding, all of the areas have been fertilized with about 225 $kg.ha.^{-1}$ of an N, P, K mixture annually. We do not know whether the current vegetation can be maintained without annual fertilization. Therefore, not until we know more about the stability of the revegetation communities can we assert that the reclamation areas are, in fact, "reclaimed".

Methods of sampling vegetation.

This is one of the thornier problems facing the reclamationist. Care must be taken not only to employ sound statistical design but also to measure the vegetation in a meaningful way. The method of measurement employed, of course, depends on the objectives of the study. If forage production data is desired then direct clipping and weighing the plants' annual production yields the most reliable estimate. However, this can be very time consuming and, if the vegetation on small trial plots is to be assessed, prohibitively self-destructive. Farmer, et.al.(1974) successfully used the Neal Capacitance Meter, Model 18-1000 (Neal and Neal, 1973) to measure the aerial production on their trial plots at the Decker coal mine in southeastern Montana. This instrument greatly reduces both time and labour, though clipping of every sixth sample is necessary for calibration.

Table 1

AERIAL PRODUCTION AS OF LATE JULY/EARLY AUGUST, 1975

OF THIRTEEN REVEGETATION SPECIES ON EIGHT RECLAMATION AREAS.

Area Elevation(m) Aspect	Michel Pile 1,176 E. to N.	Baldy 1,413 S. W.	Erickson 1,610 South	McGilvary 1,610 North	Lower C 1,674 S. W.	C seam 1,771 West	D seam 1,868 West	Assembly Pad 2,190 0-West
Agropyron desertorum	347.9	21.2	133.4	106.2	36.4	16.3	26.0	0
Agropyron intermedium	0.5	29.8	137.0	95.1	9.4	3.4	14.4	0.1
Agrostis alba	14.3	21.4	4.3	2.7	9.4	2.3	12.9	0
Bromus inermis	18.8	118.8	30.1	36.4	38.7	33.7	61.3	3.9
Dactylis glomerata	0.4	5.1	0.4	0	228.9	127.7	164.3	19.7
Festuca rubra	4.9	55.4	19.4	89.9	7.4	18.9	37.7	0.6
Lolium perenne	0	2.3	124.3	469.1	402.9	230.8	501.3	88.6
Phleum pratense	41.3	29.9	49.3	300.8	0	0.4	0.1	15.1
Poa compressa	145.7	3.5	28.3	205.5	0	0	0	0
Medicago sativa	0.1	8.2	602.9	1,090.2	1,189.5	738.5	343.2	6.3
Melilotus officinalis	0	19.1	40.9	4.3	5.0	16.4	7.2	1.7
Trifolium pratense	0	0.5	0	0.6	504.4	209.5	112.6	0
Trifolium repens	0	7.0	6.4	0	226.4	99.6	119.5	0.3
Totals	573.9	322.2	1,176.7	2,392.8	2,658.4	1,497.5	1,400.5	136.3

Table 2

FORAGE PRODUCTION DATA OF SOME RANGE TYPES FLORISTICALLY SIMILAR TO THOSE FOUND ADJACENT TO THE EIGHT RECLAMATION AREAS. 1/

Range type	Aerial Production (kg ha $^{-1}$)	Source	Reclamation area	Aerial production (kg ha $^{-1}$)
Mixed prairie (Manyberries, Alta.	623	Smoliak, 1965	Michel Pile	573.9
Lodgepole Pine - Pinegrass (near Kamloops, B.C.)	561	Freyman and Van Ryswyk, 1969	Baldy	322.2
			Erickson	1,176.7
			McGilvary	2,392.8
			Lower C	2,658.4
			C seam	1,497.5
			D seam	1,400.5
Mountain grassland (S.W.aspect, Montana)	813	Mueggler, 1972	Assembly Pad	136.3

1/ The data are presented only to aid in interpretation of the reclamation area production data and do not necessarily represent the true forage production on the adjacent undisturbed areas.

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RECLAMATION OF MINED LANDS, GREAT CANADIAN OIL SANDS LTD. LEASE SITE, TAR ISLAND, ALBERTA

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Introduction

In the open pit method of mining oil sands at the Great Canadian Oil Sands (G.C.O.S.) lease site, two operations are performed, creating a land disturbance and other environmental impacts. Overburden is placed in waste dumps in areas uneconomical to mine. The oil extraction process produces large quantities of tailings sand used in dyke building for impoundment of liquid tailings. The tailings sand dyke and overburden waste dump are illustrated in Figures 1 and 2, respectively.

Tailings sand is a fine-textured, high pH (8.0-8.5), low nutrient and poor water holding material. Overburden spoil, generally, is saline, above neutral in pH, high in clay content, low in organic matter, low in fertility, and may contain a small percentage of oil sands. The overburden component muskeg, usually a sedge or moss peat, is the principal amendment used to improve the adverse characteristics of tailings sand and overburden spoil.

Our reclamation program is designed around the primary short-term objective of erosion control and secondary objectives of establishing a self-supporting vegetative cover, improving aesthetics and providing a habitat for wildlife.

Description of Program

1. Revegetation Progress from 1969 to 1975

Growth room experiments were initiated in co-operation with the Alberta Department of Agriculture in 1969, followed by field verification in 1970. Applying the recommendations of the laboratory and field work, operational revegetation commenced on our tailings dyke in 1971. To date 140 acres are under vegetation.

In 1974, laboratory experiments by the Alberta Environment and field testing by the Alberta Forest Service set the basis for revegetation of 40 acres of an overburden waste dump in 1975.

To date, 35,000 trees and shrubs have been planted on the tailings dyke and overburden waste dumps in various experimental combinations. The afforestation program, in co-operation with the Alberta Forest Service, serves a twofold purpose at this stage - the actual afforestation of these areas and field experimentation.

2. Methods

A four(4) inch cover of muskeg is incorporated with fertilizer into the tailings sand slope at a volumetric ratio of one-to-one by using a rotovator. Seeding was initially accomplished by hydroseeder; however, better results were obtained with a Brillion Grass Seeder (see Figure 3 for seeding and fertilizer rates and mixtures).

The overburden waste dump was handled differently, using a disc and/or harrows to mix fertilizer and muskeg into the slope surface. Seeding and fertilizing was accomplished by a Cyclone Broadcaster mounted on the rear of a Bombardier. Seed and fertilizer was harrowed into the seedbed.

Maintenance fertilizer was initially applied manually, then by broadcaster on Bombardier,and by helicopter once the areas were large enough to be economical.

Trees and shrubs are generally planted at a density of 430 per acre. The ratio of coniferous to deciduous species has been about 2 to 1. As suitable nursery stock becomes available this ratio will be changed to 1 :to 4. Native stock propagated from locally collected cuttings and seed, now introduced as propagative technology, is being developed. Trees and shrubs are generally planted in established grass and legume cover with scarification at each seedling planting site. All seedlings, container and bare-root, are hand planted and watered if required at time of planting.

3. Results

By the end of the second growing season the grass and legume cover is dense and uniform enough to control water and wind erosion on the tailings sand slopes. Generally, the proportion of grasses in the plant cover,in the second season, is 50%. After the second growing season the legumes are phased out with Creeping Red Fescue becoming the dominating species. There is evidence of invasion by native species as well as volunteer growth, probably propagating from vegetative material in the muskeg.

The tree and shrub survivals have been increasing as methods improve, more adaptable species are available and nursery stock of good quality becomes available. Figure 4 represents survival rates of various species planted over the past four years. To date, lack of moisture (in 1972 and 1973) and mouse damage have been the major contributing factors to mortality.

Other factors affecting survival and growth which are being studied are species suitability, time of planting, type of herbaceous cover, uncontrolled water erosion, quality of nursery stock and nutrient status.

4. Government Involvement

Government activity has been at a high level recently with most of the ongoing projects now being directed through the Alberta Oil Sands Environmental Research Program. This program is a joint agreement established last year between the federal and provincial governments to undertake the task of researching environmental problems associated with oil sands development.

Major ongoing projects are summarized as follows:

- Alberta Forest Service: testing of native and introduced tree and shrub species.
- Alberta Agriculture: testing of native and introduced grass and legume species.
- University of Alberta Soil Science Department: fertility studies, soil properties, nutrient movement.
- Canadian Wildlife Service: small mammals study to control mouse problem on vegetated dyke slopes.

Other agencies involved,in the past,were the Alberta Agriculture Soils Division, Alberta Environment Earth Licensing Division and Environment Canada Forestry Service.

Future Considerations

1. The major cost of reclaiming oil sands mined land is the handling of muskeg. More needs to be known of storage effects and investigation into handling methods.

2. We will have to intensify research into the testing of native vegetation, technology of seed production and handling and establishment of a source of supply in hopes of achieving a self-supporting plant cover.

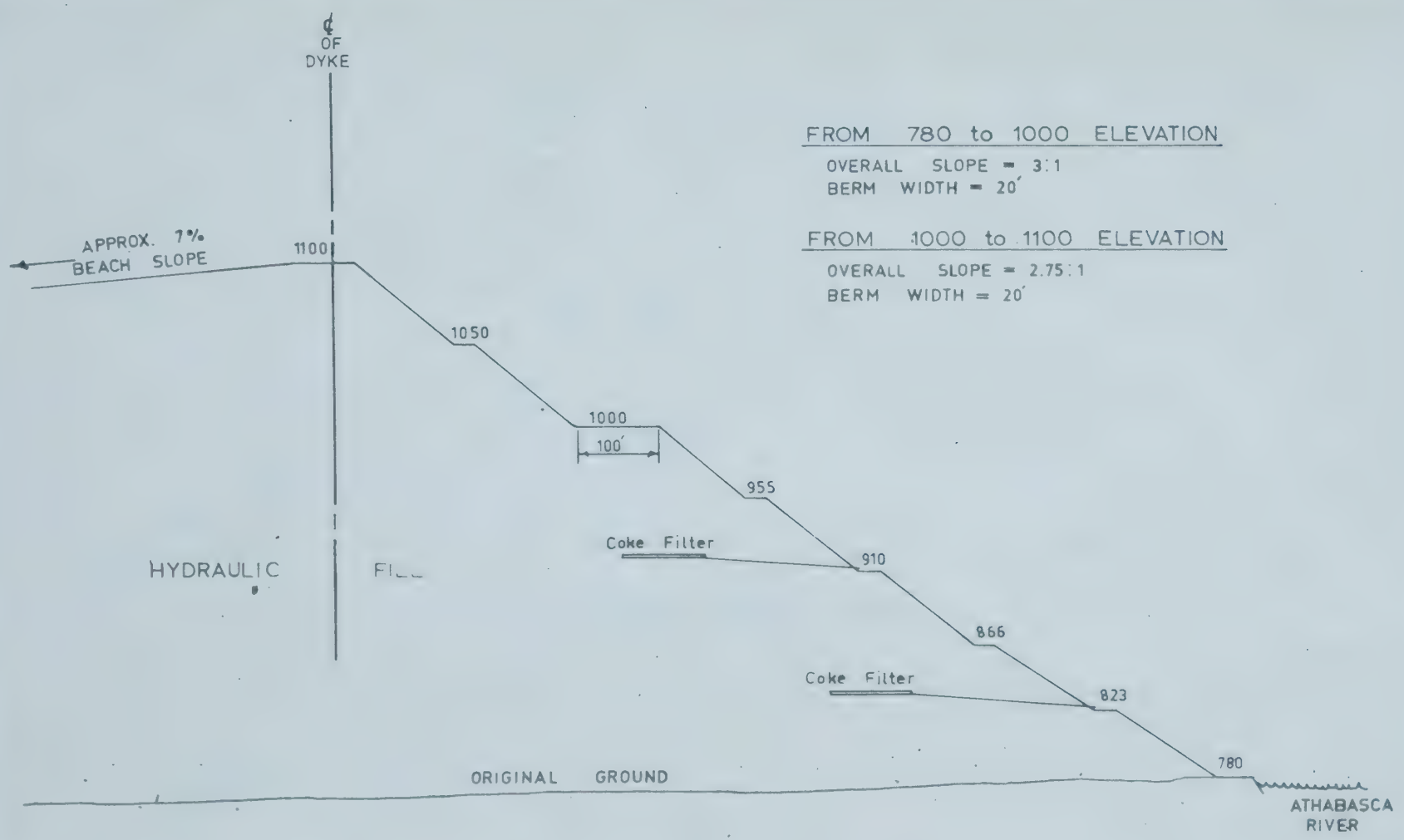
3. More attention must be devoted to the control of surface water runoff on tailings sand slopes. This problem overlaps into engineering aspects of dyke design and construction. We are planning the installation of a comprehensive surface drainage system in 1976.

Future Considerations (continued)

4. A word or two should be said on our long-range plans. In preparation for a long-range reclamation plan, muskeg and/or topsoil material will be inventoried and sampled this winter. The reclamation of 200 acres of tailings dykes and overburden waste dumps and the planting of 100,000 trees and shrubs would not be an unrealistic projection for the next five years. Larger areas will be reclaimed as mining advances and the mine pit is backfilled with tailings sand.

Conclusion

This report presents the G.C.O.S. Reclamation Program in a nutshell. As is evident from the problems described herein, more research is required. However, we are optimistic that a total effort by government, industry and others concerned could reclaim mined oil sands land to an ecologically acceptable condition.



TYPICAL SECTION OF SAND DYKE

SCALE: HORZ.- 1"= 200'
VERT.- 1"= 100'

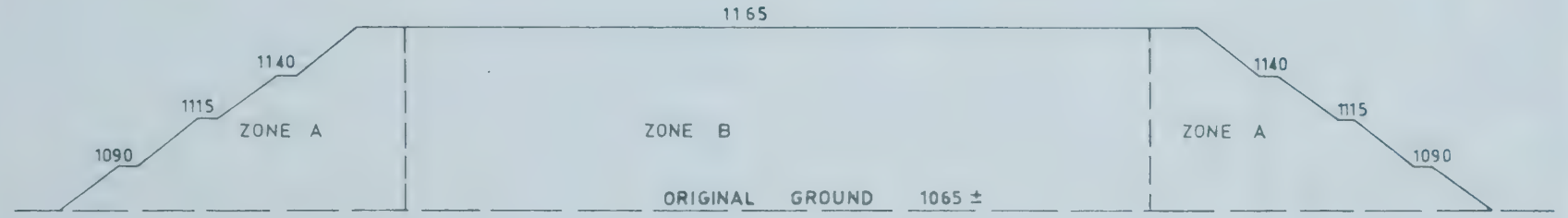
FIGURE I

MATERIAL PLACEMENT

ZONE A – GOOD FILL MATERIAL

ZONE B – MUSKEG & SILT

NOTE OVERALL SLOPE = 3:1
BERM WIDTH = 20'



TYPICAL SECTION of OVERBURDEN WASTE DUMP

SCALE: HORZ. – 1" = 200'
VERT – 1" = 100'

FIGURE II

FIGURE 3 (a) SEEDING MIXTURES & RATES

SPECIES	TAILINGS DYKE - 1974		WASTE DUMP - 1975	
	% BY WEIGHT IN MIXTURE	RATE IN LB/AC	% BY WEIGHT IN MIXTURES	RATE IN LB/AC
Grasses	-	15	-	18
Bromegrass	34	-	20	-
Crested Wheat-grass	27	-	17	-
Creeping Red Fescue	15	-	6	-
Slender Wheat-grass	-	-	17	-
Legume	-	5	-	12
Sweet Clover	7	-	17	-
Alsike Clover	7	-	13	-
Alfalfa	10	-	10	-

FIGURE 3 (b) FERTILIZER COMPOSITION & RATE

SPECIES	TAILINGS SAND			OVERBURDEN		
	LBS/AC			LBS/AC		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
1st Growing Season						
Starter	12	48	48	23	23	0 *
Mid-Summer	40	-	-	23	23	0
Maintenance	40	30	20	60	50	50

* No potassium was applied because soil tests showed sufficient available potassium.

TAR ISLAND TAILINS DYKE
TREE AND SHRUBS

FIGURE 4(a) PLANTED IN 1972

SPECIES	% SURVIVAL			
	1972	1973	1974	1975
Caragana arborescens	56.6	45.0	45.0	45.0
Poplar-Populus griffithi	62.0	17.0	17.0	17.0
Aspen-Populus tremuloides	24.0	2.0	0.0	0.0
Birch-Betula papyifera	52.0	16.0	15.0	15.0
Elm, Manchurian-Ulimus pumila	99.0	80.0	79.0	60.0
Pincherry-Prunus pensylvanica	74.0	33.0	25.0	17.0
Choke Cherry-Prunus virginiana	36.0	28.0	25.0	7.0
Buffalo Berry-Shepherdia argentea	15.0	0	0	0
Wolf Willow-Elaeagnus commutata	28.0	2.0	2.0	2.0
Willow-Salix spp	28.0	28.0	25.0	7.0
Jackpine-Pinus banksiana	15.0	15.0	15.0	15.0
White spruce-Picea glauca	9.0	9.0	9.0	9.0

FIGURE 4(b) PLANTED IN 1973

SPECIES	% SURVIVAL		
	1973	1974	1975
Poplar-Russian	36.0	13.0	8.0
Willow-Salix spp	60.0	28.0	17.0

FIGURE 4(c) PLANTED IN 1974

SPECIES	% SURVIVAL	
	1974	1975
Aspen-Populus tremuloides	50.0	32
Poplar-Balsam-populus balsamifera	4.0	2
Birch-Betula papyrifera	24.0	19
Willow-Salix spp	4.0	2
Spruce-Picea glauca	92.0	88
J.Pine-Pinus banksiana	72.0	66
Lodgepole Pine-Pinus contorta	44.6	43
Pine-Hybrid	48.0	45
Balsam Fir-Abies balsamea	30.0	4

FIGURE 4 (d) PLANTED IN 1975

SPECIES	% SURVIVAL
	1975
Pinus banksiana-Bare Root	61
Pinus banksiana-Containers	49
Pinus contorta - Containers	51
Picea glauca	51
Picea mariana	36
Alder - Native	24
Willow - Salix spp	88
Maple - Acer negundo L.	77

OVERBURDEN WASTE DUMP No. 7
SEEDLINGS

FIGURE 4(e) PLANTED IN 1974

SPECIES	% SURVIVAL	
	1974	1975
Spruce - Picea glauca	96	94
J. Pine - Pinus banksiana	72	55

FIGURE 4(f) PLANTED IN 1975

SPECIES	% SURVIVAL
	1975
Lodgepole Pine - Pinuscontorta	2
J. Pine - Pinus banksiana	35
Spruce - Picea glauca	74
- Picea mariana	73

LECTURES and AUTHORS

Ontario Cover Crop Committee

OAC Meeting of November 18, 1971

New cover crops for Ontario?	E. M. Watkin, ARDA - Crop Science Dept (Guelph)
Turf and fertilizer research	R. Sheard, Land Resource Science) University of J. Eggens, Horticultural Science) Guelph
Revegetation of highway rights-of-way.	H. Spence, Department of Transport & Communications.
Smother crops for hydro rights-of-way.	E. Gillespie, Ontario Hydro.
Erosion control in regional conservation areas.	J. Anderson, Department of the Environment.
Revegetation of mine tailings in northern Ontario	D. Murray, Department of Energy, Mines & Resources (Federal).
Crownvetch seed production in Ontario.	D. Bielby, Department of Agriculture and Food.
Crownvetch research in Pennsylvania.	R. Woods, Chipman Chemicals Ltd. (Presented by D. Bielby)

OAC Meeting of November 22, 1972

Review of research for hydro electric power lines	E. Gillespie, Ontario Hydro.
Review of research for highway rights-of-way.	H. Spence, Ministry of Transportation and Communications.
Review of research for wildlife (tentative)	A. Matiece, Ministry of Natural Resources.
Review of research for new cover crops.	E. Watkin, Crop Science Department

LECTURES and AUTHORS

Ontario Cover Crop Committee

OAC Meeting of November 22, 1972 (continued)

Review of research for acid-mine-tailings (tentative)	D. Murray, Department of Energy, Mines & Resources.
Review of research for turf	R. Sheard, Department of Land Resource Science, University of Guelph.
Review of research for conservation.	J. Anderson, Ministry of Natural Resources.
Commercial aspects of cover crops.	D. Webster, Sprayturf, Ltd., London.
Ecological perspectives of the use of cover crops	D. Smith, Department of Botany, U. of Guelph.
The University of Guelph/Ontario Hydro Project	L. Lester, Department of Landscape Architecture, University of Guelph.
Aspects of rehabilitation for pits and quarries	L. Caylor, Consolidated Sand and Gravel, Toronto.
Government policies in the mining industry	W. A. Hoffman, Ministry of Mines, Toronto.

O.C.C.C. Meeting of March 5, 1974

Physical and chemical methods of slope stabilization.	H. G. Lloyd, Verdyol International A.G., Basle, Switzerland.
Vegetative methods of slope stabilization	P. Tucker, Grounds Department, U. of Guelph.
Seed availability of present and potential cover crops.	W. Sieveking, Maple Leaf Mills, Georgetown, Ontario.
Revegetation of acid uranium mine wastes and municipal drainage ditches.	E. M. Watkin and J. E. Winch, Department of Crop Science, University of Guelph.

LECTURES and AUTHORS

Ontario Cover Crop Committee

O.C.C.C. Meeting of March 5, 1974 (continued)

Ministry of Transportation & Communications Development re: Hydro-mulch.	N. McKenna, Ministry of Transportation & Communications, Downsview.
Ontario Hydro - Research in Progress Report	E. D. Gillespie, Ontario Hydro, Toronto.
Ditchbank Seeding Trials at R.C.A.T.	M. Sojack, Ridgetown College of Agriculture Technology, Ridgetown, Ontario.

O.C.C.C. Meeting, December 1974

Reclamation studies on industrial barrens in the Sudbury area.	Keith Winterhalder, Laurentian University, Sudbury.
Ontario Hydro - Progress Report.	E. D. Gillespie, Ontario Hydro, Toronto.
Some questions pertaining to the reclamation requirements of future lignite strip-mining in northern Ontario.	Q. F. Hess, Ontario Ministry of Natural Resources, Toronto.
Species suitability to various site conditions	C. J. Heeney, Ministry of Natural Resources, Toronto.
Reclamation in tar sand developments	P. Lulman, Syncrude, Ltd., Edmonton.
Possible approaches to establishment problems in northern climates.	M. C. Pick, Otto Pick & Sons' Seeds, Ltd., Richmond Hill
Progress report on mulch evaluation studies.	A.J.Stripnieks & N.McKenna, Ministry of Transportation & Communications, Toronto.
The use of pelleted seed in crop establishment.	G. Eros, OSECO Ltd., Brampton.
The erosion process & vegetative stabilization of Great Lakes bluff areas	W.S. Haras, Environment Canada, Burlington.
Upward leaching into overburden and hydrology of the nickel rim tailings	A.C.Spires & G.M.Courtin, Laurentian University, Sudbury.

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